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SURGERY

A Monthly Journal Devoted to the Art and Science of Surgery

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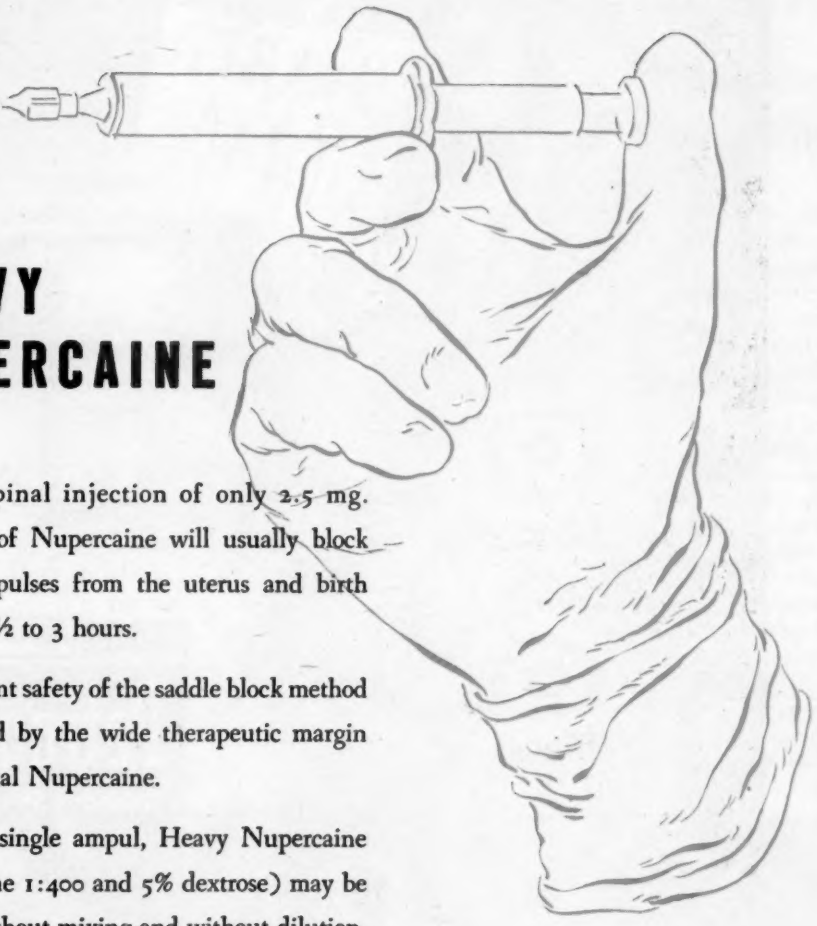

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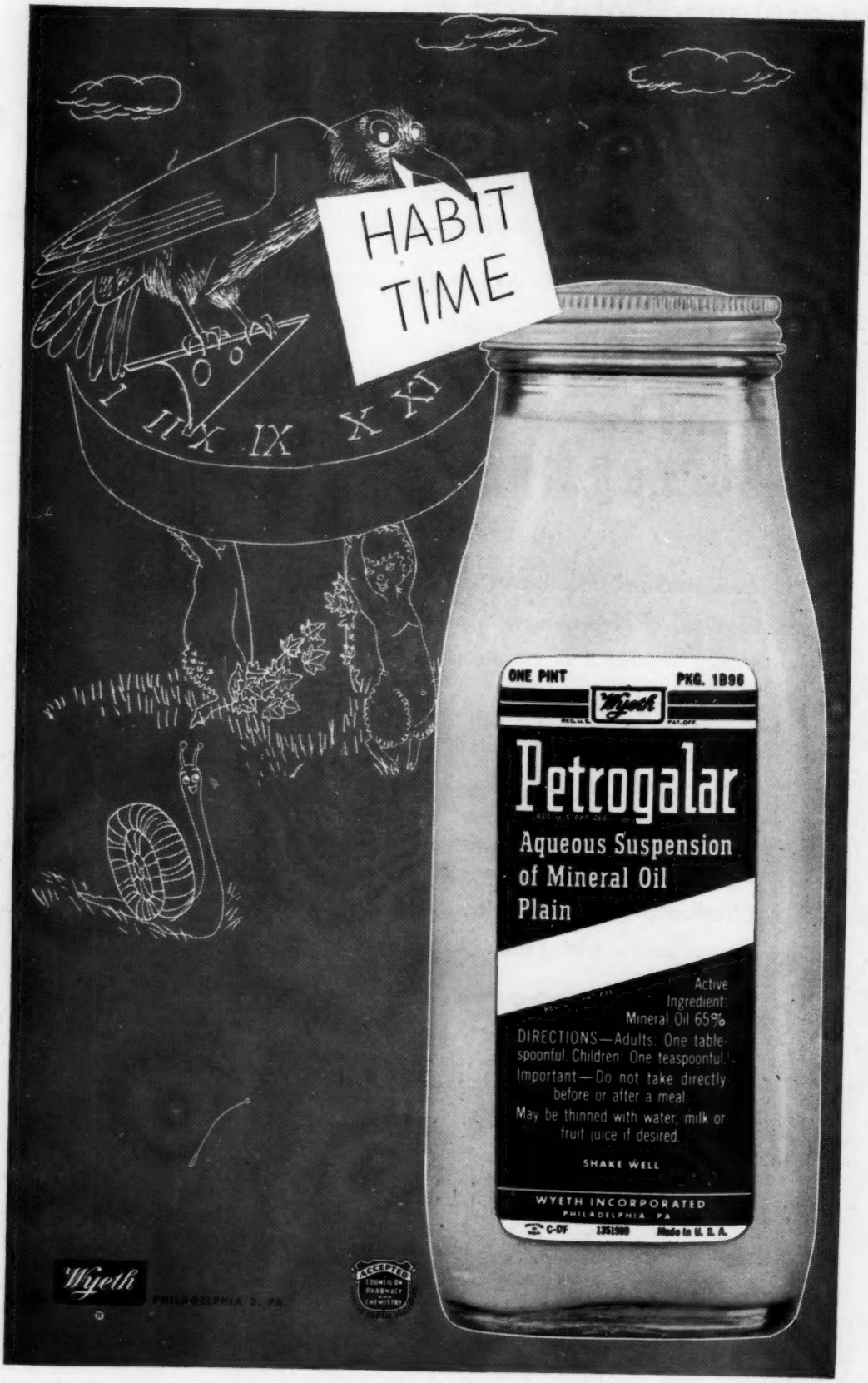
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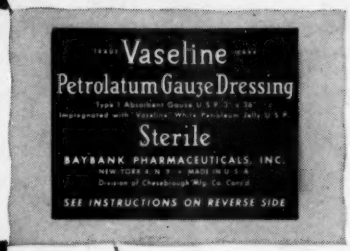

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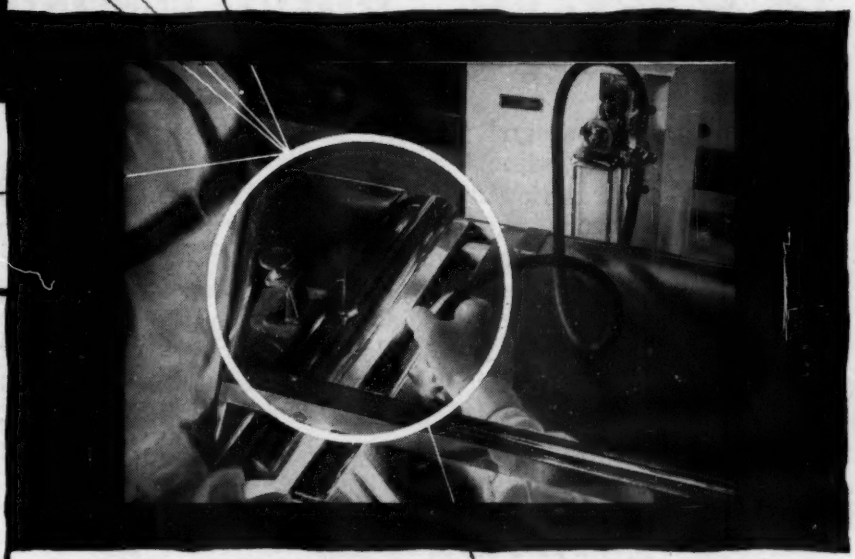

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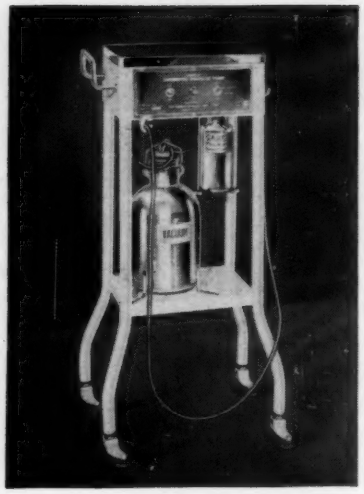

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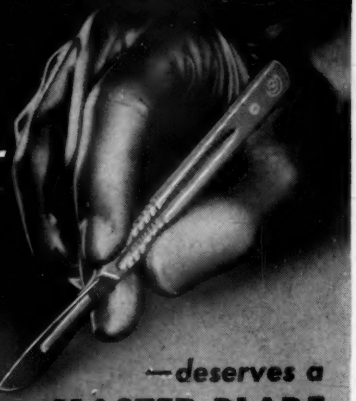

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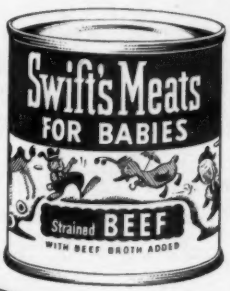

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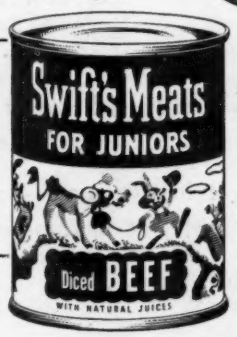

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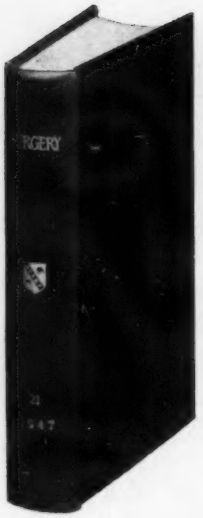

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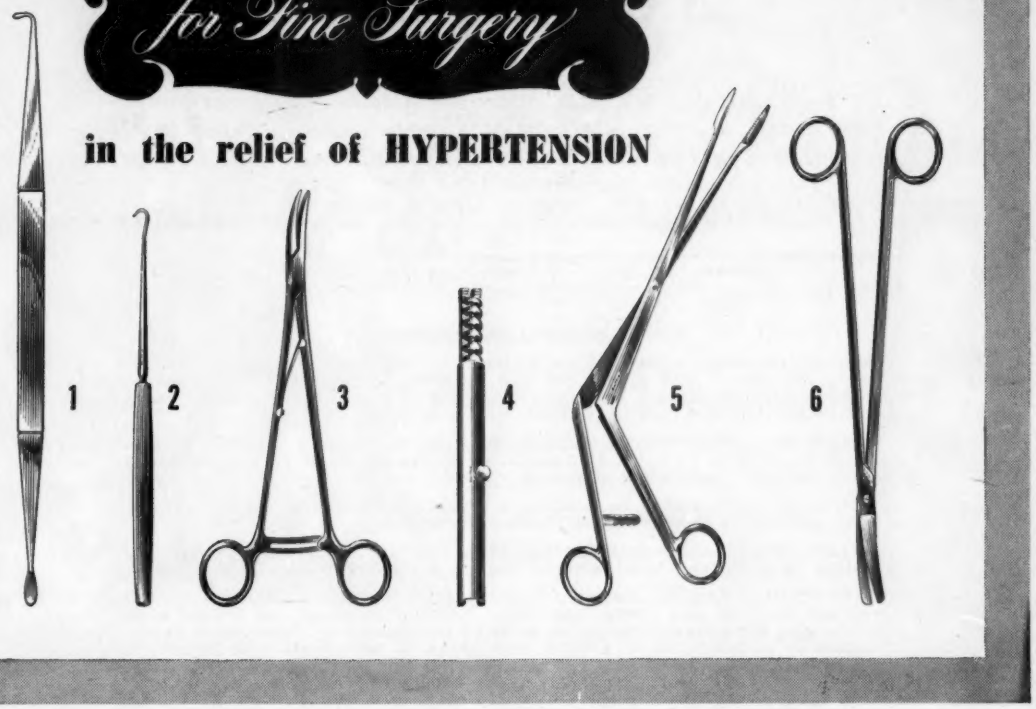

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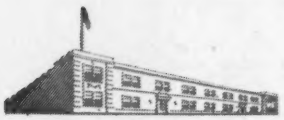

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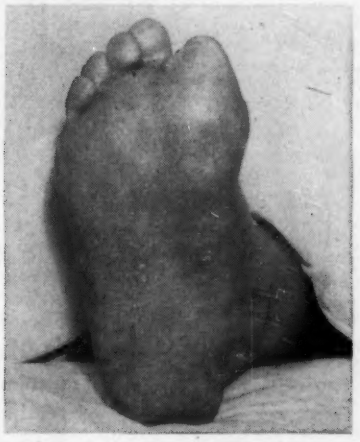

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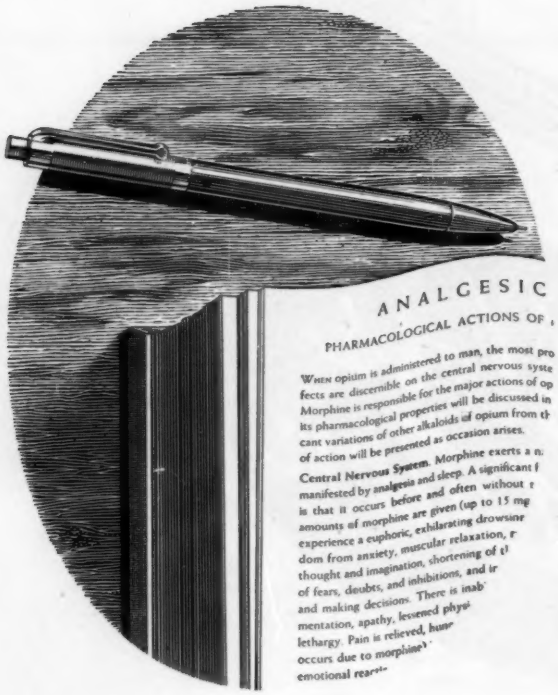
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Original Communications

TREATMENT OF SHORT STRICTURE OF THE ESOPHAGUS BY PARTIAL ESOPHAGECTOMY AND END-TO-END ESOPHAGEAL RECONSTRUCTION

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FOR several decades the standard form of therapy for congenital or for chemical burn strictures of the esophagus has consisted of repeated esophageal dilatations, combined in some instances with a gastrostomy for purposes of feeding or for retrograde bougienage. This form of treatment has usually been satisfactory; it has been practiced in this hospital for approximately thirty years in a large number of patients without fatality. While the method produces a good end result in the majority of cases, it has drawbacks in some instances because (1) the esophageal cicatrix may be unyielding, (2) repeated dilatations over a period of years may be necessary and (3) the economic factors may be formidable when many hospitalizations are required. These three considerations indicate that a more radical form of therapy might be advantageous (for a minority group of patients) since it would presumably offer a quicker, a less troublesome, and a much less expensive relief of the patients' swallowing difficulties.

A radical attack on the problem of impermeable stricture of the esophagus has been made previously by the establishment of some form of antethoracic esophagus. Such undertakings have had great impetus from the recent work of the Russian, Yudin,[4] who reported the surgical treatment of eighty patients by stage operations which consist of division of the jejunum, bringing up the distal loop of the jejunum in front of the thoracic cage for anastomosis with the esophagus in the neck above the stricture, and re-establishment of the continuity of the upper intestinal tract by anastomosing the proximal end of the divided jejunum to the lower jejunum or the upper ileum. Yudin's mortality rates have

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been amazingly low and the end results have been satisfactory from the standpoint of function. Yudin's method has the disadvantage of completely sidetracking the stomach, duodenum, and upper jejunum; these are thrown out of function except for their activity in producing alimentary juices. It is important to point out that most of Yudin's subjects were adults. In our clinic, attempts at similar jejunal transplantation in children (for treatment of esophageal atresia) have been troublesome, or have failed, because of the shortness of the loop which can be brought up onto the chest or because of insufficient blood supply (and sloughing) of this limb. While the method of Yudin represented a tremendous advance in surgical thinking, I believe it is already relegated to a position of purely historical interest because of the more logical and the safer procedure developed by Sweet[2] and others, which consists of subtotal esophageal resection combined with a high intrathoracic esophagogastric anastomosis. This operation employs the stomach for replacement of that portion of the esophagus which has been removed. Most of the stomach is displaced upward into the thorax so that it can be joined at a high level to the proximal end of the esophagus. Sweet has accurately described this procedure and has recorded three cases in which it was successfully performed for treatment of extensive and impermeable esophageal stricture. While his method offers excellent relief if an esophageal stricture is extensive, I believe it would be unnecessarily radical in the treatment of a resistant stricture which is limited to a short segment of the esophagus. For this latter type of case, I would like to propose an excision of the narrowed portion of the esophagus and reconstruction of the esophageal tube by end-to-end suture of its remaining portions.

A decade ago an end-to-end suture of the esophagus would have been regarded as a technical impossibility; the risks attending such anastomoses were prohibitive. However, in recent years extraordinary advances have been made in the treatment of congenital atresia of the esophagus by end-to-end suture. Holt and associates[1] have reported twenty-six cases in which there has been survival following such reconstruction in newly born babies, and at the Children's Hospital of Boston thirty patients have been successfully treated by such primary anastomoses. This experience has convinced me that the esophagus can be widely raised from its bed with impunity, that large gaps in the esophageal tube can be overcome, and that end-to-end unions heal in a satisfactory way—provided one's technique is gentle, the esophagus is not traumatized unnecessarily, and the anastomosis is accurately and meticulously performed. The success which has attended the performance of such operations in small babies, combined with the recent experimental observations of Swenson and Clatworthy,[3] has led me to the conviction that it would be technically feasible to remove a stenosed segment of esophagus and then join the remaining ends of the esophageal tube by appropriate suture. Whenever this procedure is applicable for treatment of a short stenosis of the esophagus in a child, it would seem to be preferable to the method of Sweet wherein the stomach is displaced up into the chest because the former gives a more normal anatomic reconstruction of the alimentary pathway and because it does not in any way interfere with the functions of the stomach.

The practicality of excising portions of an esophagus and joining the remaining ends by direct suture is demonstrated by the case report which is made herewith. As far as I am aware, this is the first successful resection of an intrathoracic portion of the esophagus in a human being with reconstruction of the esophageal tube. Some technical considerations of such an operative procedure can be summarized as follows:

TECHNICAL CONSIDERATIONS OF OPERATION

1. *Avenue of Approach to the Esophagus.*—There is much to be said in favor of a retropleural approach to the esophagus, without traversing the pleural cavity. This has been preferred when making a direct anastomosis of the esophagus in babies with atresia of the esophagus. It maintains a reasonable degree of expansion of the lung during the operation, it eliminates contamination of the pleural cavity during operation, it gives maximum protection of the pleural cavity if there should be any postoperative leakage from the esophageal suture line, and it provides a direct route for external drainage if suppuration or esophageal leakage should occur. These considerations are all cogent reasons for using the retropleural approach in babies, where it is so important to maintain the integrity of the pulmonary system. In older subjects, such as those being explored for strictures of the esophagus, the more direct route to the esophagus by the transpleural approach seems to be preferable because it gives a wider exposure and because the mediastinal pleura will now be thick enough to permit its careful closure at the end of the operation for reconstruction of a partition between the mediastinum and pleural cavity.

2. *Side of Chest for Operative Approach.*—The esophagus can be approached satisfactorily by either the right or the left transpleural route, but mobilizing it from its bed (particularly beneath the aortic arch and at the thoracic apex) is accomplished much more easily from the right side. However, an exposure through the right side will not permit the stomach to be brought up into the chest if a longer segment of esophagus than anticipated has to be resected and the fundus of the stomach has to be employed for re-establishment of the alimentary tract continuity. If, before operation, it appears that the esophageal stenosis is short and an esophageal reconstruction can surely be effected (as in the case here reported), the operation is greatly facilitated by making the chest incision in the right side. But if before operation it is difficult to predict whether removal of an esophageal segment will allow esophageal reanastomosis—or whether a more formidable gastric mobilization and esophagogastric anastomosis will be required—then it is distinctly preferable to approach the esophagus via the left transpleural route.

3. *Chest Incision.*—A wide variety of chest incisions has been employed for gaining access to the esophagus, and indeed it is well to avoid rigid standardization, to allow for variation in the level of esophageal lesion which is being exposed. In the case herein reported a long intercostal incision running the entire length of the sixth interspace, with severance of the sixth and fifth costal cartilages, gave an entirely adequate view. In older subjects where the costal cage is less yielding, it might be necessary to divide several ribs posteriorly to provide a T-shaped wound. The severance of ribs posteriorly almost

certainly increases the patient's discomfort during the early postoperative period, but this should be accepted, when necessary, rather than hamper the proper performance of an operation by inadequate exposure.

4. *Entrance to the Mediastinum.*—Since the reconstruction of a protective bulkhead between the mediastinum and the pleural cavity at the end of operation is a highly important step, great emphasis should be placed upon the preservation of the parietal pleura, which covers the esophagus. The longitudinal opening of this layer should not be made directly over the bulge of the esophagus; it is preferably made in front of the esophagus so that a broad flap of pleura can be raised and turned backward in such a way that this tissue can be utilized later for covering over the esophagus.

5. *Raising the Esophagus From Its Bed.*—The esophagus must be widely freed and elevated from its bed, a point of great importance if its ends are to be brought together without too much tension after excision of a stenosed segment. The poor vascularity of the esophagus has been commented upon by many authors, but an increasing experience with esophageal surgery indicates that the esophagus can be mobilized from the diaphragm to the apex of the chest and still have sufficient blood supply to be viable. Of course, as much blood supply as possible should be saved, but there need be no hesitation about freeing the entire intrathoracic portion of the esophagus if this is essential for the resection and reconstruction which is being contemplated.

An esophagus is in some ways a very delicate structure and every effort should be made to avoid traumatizing it. Any part to be saved should not be grasped with forceps, hemostats, clamps, or other metallic instruments. By sharp and blunt dissection a tunnel can be made around the esophagus, and a linen tape can be drawn through this opening. Such traction tapes aid greatly in the further dissection of the esophagus from its bed.

Branches of the vagus nerve should be freed and protected, though this may be difficult if there are inflammatory changes in the periesophageal tissues. Posterior to the esophagus, the dissection should be kept as close as possible to the esophagus so that the thoracic duct can be left undisturbed.

6. *Identification of the Stenosed Portion of Esophagus.*—Inspection of the exterior of the esophagus may give little evidence of the exact site where the lumen is narrowed. To locate accurately the area of stenosis, a large, rather stiff catheter can be inserted through the mouth by the anesthetist and pushed down the esophagus until it meets the obstruction, at which point it can be palpated through the esophageal wall by the surgeon. Withdrawal of the catheter and severance of the esophagus will insure saving as much normal substance as possible. Probing of the lower segment under direct vision will locate the lower end of the stenotic portion and will indicate where the second transection of the esophagus should be made.

7. *Esophageal Anastomosis.*—The repair should be in two layers, interrupted stitches being used and fine, permanent, suture material, for which 00000 Deknatel silk serves admirably (in children). The outer layer includes muscularis and submucosa. The inner layer includes only the mucosa, the

stitches being so placed that the knots present in the lumen. A point of a great importance is the placement and tying of the sutures in the posterior surface of the muscularis. It is almost impossible to snug up and tie each stitch as it is placed, because this places great stress on each of the early stitches and they will tear out of the eophageal wall. Instead, it is better to place *all* of the posterior stitches and then draw them up simultaneously; this distributes the pull through all of the stitches, permits the ends of the esophagus to be drawn together, and then the individual sutures can be tied. Stitches in the outer and inner layers should be placed only 2 or 3 mm. apart.

While "closed" anastomoses would have some theoretical advantage, there is good reason to believe that "open" types of anastomoses in the esophagus are tolerated with a very low risk. It is hardly necessary to emphasize that serious contamination of the chest can be avoided by adequately packing off the small operative field from the remaining pleural cavity and by subsequently discarding these packs, any contaminated instruments, and the operator's gloves before proceeding with the chest closure.

After completion of the anastomosis, penicillin and streptomycin solutions can be flushed into the chest, but I rely more upon a careful operative technique which reduces soiling to a minimum than I do upon the indiscriminate dumping of chemotherapeutic agents into a chest.

While crushing of the phrenic nerve might reduce some of the tension or movement of the esophagus during the postoperative period, I have little faith in this procedure and do not believe that it is worth doing.

8. *Mediastinal Drainage.*—While it may be possible in some cases to close the mediastinum without drainage, it would seem far safer to provide some temporary opening for four or five days which allows for escape of serum or lymph. This can be accomplished by a stab wound through the back, just outside of the erector spinae muscles, leading through an intercostal space above (or below) the main chest incision and burrowing bluntly behind the parietal pleura to reach the mediastinum. A soft rubber drain can be pulled through the channel thus formed.

Of prime importance is the suture of the mediastinal pleura over the esophagus so that the mediastinal and pleural compartments will be sealed from one another. This gives the best assurance that the lung can be kept re-expanded and that the pleural cavity will probably be protected if infection or leakage should develop at the esophageal anastomosis during the postoperative period. Careful closure of the pleural sac will allow the pulmonary system to be returned immediately to its full function; at the same time provision can be made for any postoperative mediastinal suppuration by leading a mediastinal drain out through the back, as mentioned previously.

9. *Chest Closure.*—Before repair of the lateral chest wound, a rubber catheter is led out from the pleural cavity through the subjacent intercostal space. For four or five days following operation suction is constantly applied to this intrapleural catheter to keep the pleural space evacuated.

10. *Gastrostomy.*—Experience with anastomoses for atresia of the esophagus has shown that it is sometimes possible to feed in a few days through the reconstructed tube. As an alternative it is possible for an extended period of time to leave an inlying catheter which is threaded through the nose and esophagus and led into the stomach. However, it is becoming increasingly evident that it is far wiser to establish a gastrostomy routinely for feeding purposes so that the esophagus can be given the best chances for healing during the early postoperative period. Such a gastrostomy rarely needs to be kept open more than a few weeks. I believe the same general principles and precaution should be adopted for the postoperative care of patients who might be subjected to esophageal resection for esophageal stenosis. Indeed, it is almost inconceivable that patients in this latter category would be subjected to esophagectomy unless a gastrostomy had been previously established for purposes of improving the general nutrition.

CASE HISTORY

D. S., an 11-month-old boy, was admitted to the hospital Jan. 23, 1947, because of intermittent vomiting since birth. This had become much more severe in the past six weeks; during this interval the child could not retain any solid food and lost seven pounds. Immediately prior to hospital entry he had been studied in another institution for ten days where barium studies showed evidence of esophageal obstruction. For about ten days there had been a moist nonproductive cough.

On physical examination the child had some evidence of weight loss, but was fairly well hydrated. Weight was 19 pounds, 4 ounces. The respirations were rapid and auscultation disclosed numerous, moist, coarse râles throughout both lung fields.

A roentgenogram of the chest showed slight accentuation of the lung markings at the right base but no definite evidence of infiltration. Visualization with a barium swallow showed marked dilatation of the proximal half of the esophagus and an unusual congenital malformation with marked stenosis of the middle portion of the esophagus and a posterior, narrow communication between the dilated upper end of the esophagus and the smaller lower half of the esophagus (Fig. 1). There was considerable obstruction to the passage of thin barium through the esophagus.

Course.—Because of the progressive recent weight loss and inability to swallow a sufficient amount of milk to maintain adequate nourishment, a gastrostomy of a Stamm type was established on Feb. 3, 1947.

On Feb. 18, 1947, under general anesthesia an esophagoscope was passed from above to visualize the narrowed portion of the esophagus. On the posterior wall of the esophagus, just above its blind end, a tiny opening could be seen. Attempts were made to feed a ureteral catheter down through this opening in the hope that it could be threaded into the lower esophageal segment and fished out through the gastrostomy. It was our intention to pull a string through the narrowed area which would be employed as a guide for subsequent dilatations. The catheter would go through the tiny opening for only a short distance and then it constantly met some obstruction so that it could not be pushed downward. The gastrostomy tube was now removed and a small scope was introduced through this opening and led up into the lower end of the esophagus in an effort to pass a ureteral catheter (followed by a string) in a retrograde way through the tiny esophageal opening. A small opening, about 3 mm. in diameter could be viewed; the scope could not be passed through it, and a ureteral catheter could be pushed through it for only about 1 cm., at which point it constantly met some obstruction. It seemed unwise to continue the probing and efforts at placement of an inlying string. While it is possible that subsequent attempts might have been successful in placement of a string over which dilators could have been passed, the off-set alignment of the two esophageal segments was largely responsible for the decision to

abandon conservative methods and to attempt resection of the involved portion of esophagus as soon as the general condition of the child could be built up to withstand such an undertaking. The child was discharged from the hospital on March 2, 1947, having gained to 22 pounds with the gastrostomy feedings.

On June 3, 1947, the patient was brought back to the hospital for surgical treatment of the esophageal defect. There was no evidence of respiratory infection. The general physical condition was excellent, there having been a striking gain in weight to 28 pounds, 3 ounces.

Fig. 1.—Preoperative roentgenogram of esophagus showing the stricture and the offset alignment of the upper and lower esophageal lumina.

Operation.—Exploration was undertaken June 6, 1947, under cyclopropane anesthesia, using a right transpleural approach, with a long incision in the sixth intercostal space, dividing the sixth and fifth costal cartilages. The mediastinal pleura was opened just behind the lung root, this incision being made from just above the diaphragm up to the apex of the chest, turning back a flap of pleura which had covered the esophagus. The azygos vein was doubly ligated and divided. The esophagus was exposed and was raised from its bed by sharp and blunt dissection from the second vertebral body to the diaphragm. The muscularis of the esophageal tube was a continuous layer, there being very little evidence externally of any internal derangement, in fact, it was impossible to determine accurately the level of the intrinsic obstruction. The anesthetist passed a stiff rubber catheter through the mouth and pushed it down into the esophagus to the point of obstruction, so that external palpation of the esophagus readily determined the point of blockage. A segment of esophagus 3 cm. in length was excised. The remaining ends of the esophagus were anastomosed by the technique indicated in Figs. 2 and 3. About twenty-four stitches were employed for the outer layer and a similar number for the inner layer of the anastomosis. The ends of the esophagus appeared to have an adequate blood supply. Mediastinal drainage was provided by a stab wound through the back; by blunt dissection a tract was made in behind the pleura to reach the mediastinum; through this tunnel a soft rubber wick was drawn into place. The pleural

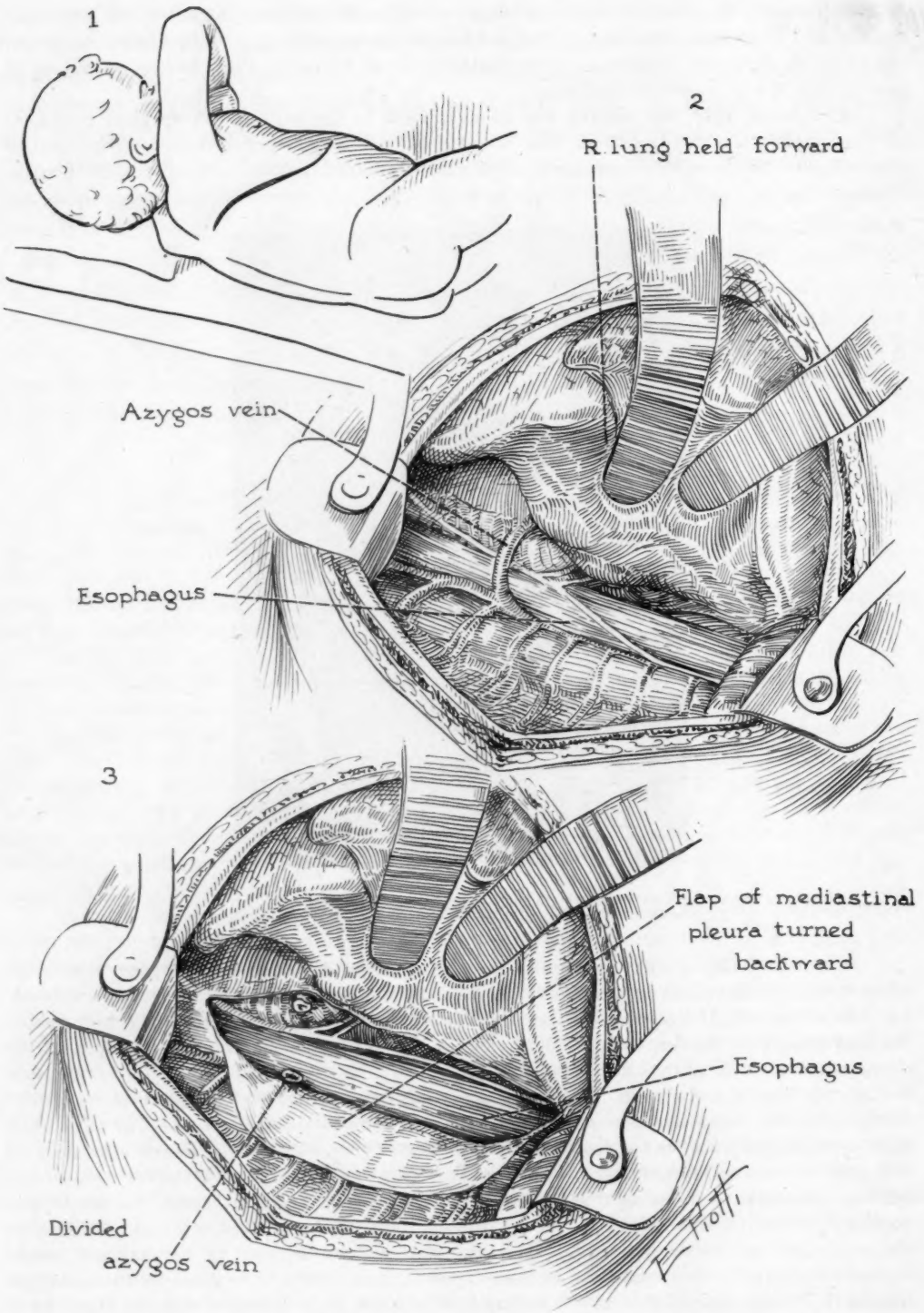

Fig. 2.—Operative procedure for partial esophagectomy. *1*, Position of thoracic wound; *2*, exposure through sixth interspace, and transpleural approach to the mediastinum; *3*, flap of mediastinal pleura reflected to expose the esophagus.

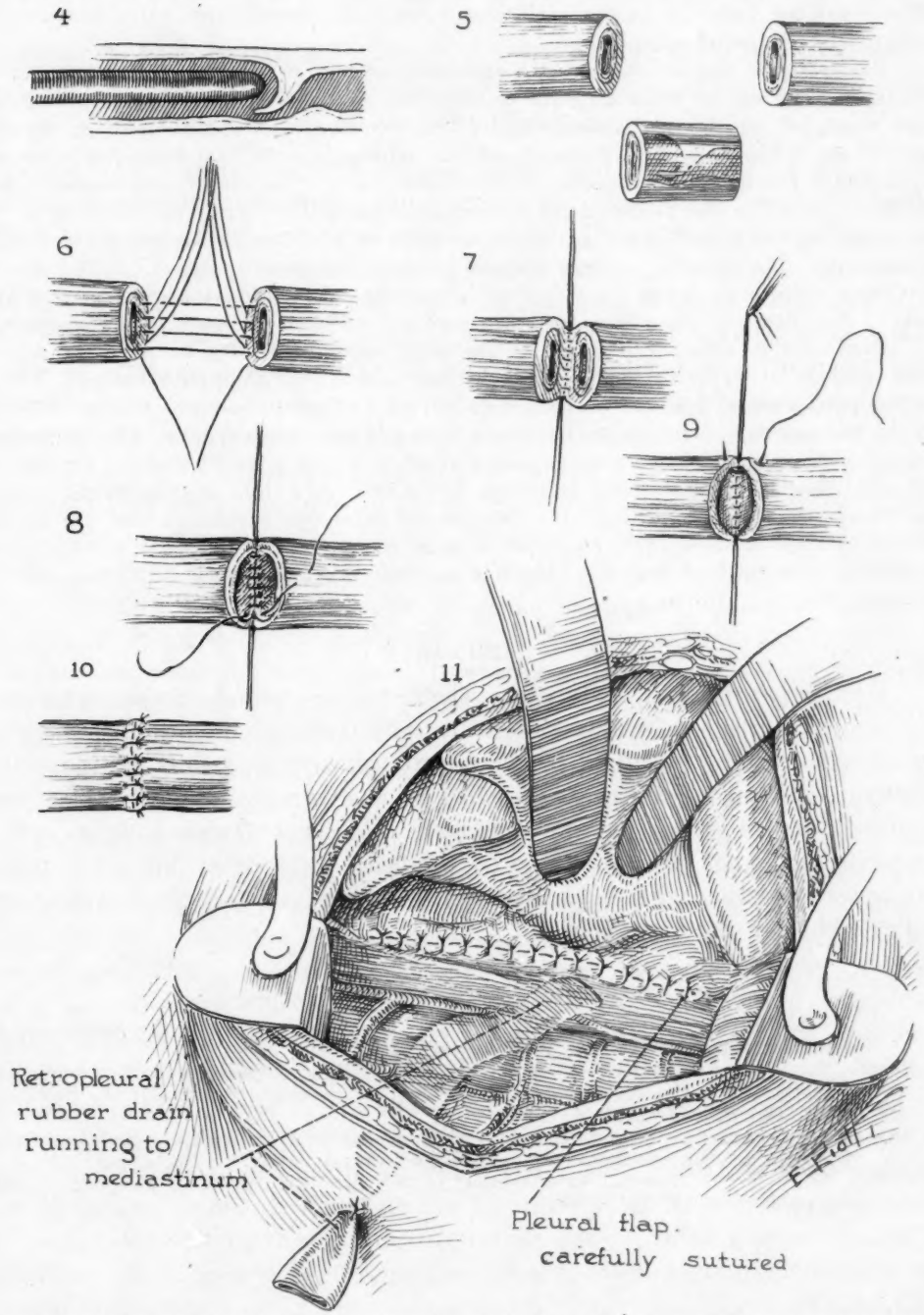

Fig. 3.—Operative procedure, continued. *4*, Large catheter passed down esophagus to identify point of obstruction; *5*, stenosed segment excised; *6*, placement of posterior row of interrupted silk sutures through muscularis and submucosa (actually, about a dozen sutures were used in this posterior row); *7*, posterior stitches drawn up and tied; *8*, mucosa being closed with interrupted fine silk sutures; *9*, mucosa entirely closed, external row of sutures being completed anteriorly in the muscularis-submucosal tissues; *10*, anastomosis completed; *11*, extrapleural drain led from back into mediastinum. Pleural covering of mediastinum closed tightly.

covering of the mediastinum was very carefully closed so that any accumulation of fluid within the mediastinum would be effectively barred from entrance into the pleural cavity. A catheter was led from the pleural cavity out through the lateral chest wall for subsequent aspiration of the pleural space.

Postoperative Course.—Suction was constantly applied to the intrapleural catheter for five days, at the end of which time the catheter was withdrawn. The posterior, soft rubber drain which led into the mediastinum by the retropleural route was withdrawn on the sixth day. There had been a slight discharge of thin serosanguineous fluid from this latter hole which ceased two days after removal of the rubber drain. The temperature reached a level of 102.4° F. on the first postoperative day and subsided to 100° F. by the fourth day. For the succeeding ten days there was a slight elevation of temperature but not above 100° F. at any time. The child had an extremely satisfactory postoperative course. Milk and other nourishing fluids were given through the gastrostomy tube during the early postoperative period. Penicillin was given by parenteral routes and sulfadiazine was given by gastrostomy for eleven days following operation. On the tenth postoperative day the child was allowed small amounts of water by mouth, which he took without the slightest hesitation. On the twelfth postoperative day sips of milk were offered and were swallowed without difficulty. On the fourteen day puréed vegetables were offered and were taken eagerly. On the sixteenth day all gastrostomy feedings were stopped and all milk was given by mouth. On this day soft solid foods were also offered and taken fairly well. The child was discharged home on the twentieth postoperative day; the gastrostomy tube was withdrawn and the opening allowed to close in six weeks. When last seen on Aug. 1, 1947, the weight was 30 pounds, deglutition was excellent, and the baby was swallowing a diet normal for his age without difficulty.

SUMMARY

Most strictures of the esophagus, whether of congenital origin or secondary to chemical burns, can be effectively treated by repeated dilatations. In certain instances intractable strictures which are extensive can be treated by the method of Sweet, wherein the diseased portion of esophagus is removed and the stomach is brought up to bridge the gap thus made. When a stenosis involves a short segment, and is not readily treated by the usual methods of dilatation, partial esophageal resection with end-to-end reconstruction is a feasible operation as is indicated by the case here reported.

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LEIOMYOMA OF THE ESOPHAGUS AND CARDIA OF THE STOMACH

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LEIOMYOMA involving both the esophagus and the cardia of the stomach is exceedingly uncommon. In a search of literature we were able to find only four cases of leiomyoma in this location. It is the purpose of this communication to report a fifth instance of leiomyoma in this location and to review the diagnosis, treatment, and reported data on these tumors. Particular attention will be given to the diagnosis of benign esophageal tumors, which, in the course of time, will undoubtedly be found and removed more frequently now that resection of the esophagus has found so sure a footing in the transthoracic resection with intrathoracic esophagogastric anastomosis.

Leiomyoma of the esophagus alone is likewise a rare disease. The clinical manifestations and symptoms of these tumors are mild or absent until great size has been attained. They are of particular interest to the surgeon because of the surgical procedures involved in their successful removal. More importantly, they are readily curable by operation and should be differentiated by clinical diagnosis from carcinoma of the esophagus and carcinoma of the stomach involving the esophagus. Leiomyomas may become leiomyosarcomas and, while the latter are usually found without metastasis, there are instances of more malignant types reported. In any event the questionable nature of some esophageal tumors may demand operative interference for diagnosis even if symptoms are minimal.

Leiomyoma of the stomach is generally considered to be a relatively rare lesion. However, Meissner,[1] in order to determine the incidence of leiomyoma of the stomach, carefully studied grossly and microscopically the organs obtained from fifty necropsies and found gastric leiomyomas in 46 per cent of these fifty individuals. The ages of the patients varied from 19 to 82 years, the majority being over 50 years. These studies indicate that leiomyoma of the stomach is a relatively common lesion. However, those tumors which give rise to symptoms remain relatively uncommon. The most alarming symptom of gastric leiomyoma is massive hemorrhage which results from ulceration of the overlying mucosa and erosion of the tumor. Gastric leiomyomas and benign gastric tumors are observed sufficiently often that preoperative diagnosis by roentgenologic examination is frequently made. The fact that operations on the stomach are a matter of almost daily occurrence in most hospitals has provided a great deal of information about gastric leiomyomas that has received careful correlation with clinical findings.

When leiomyomas involve both the stomach and the esophagus, diagnosis may be very difficult before operation. It is possible that erosion of the gastric portion of the tumor may result in massive gastric hemorrhage or chronic anemia; on the other hand the symptoms of esophageal obstruction may predominate.

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BENIGN ESOPHAGEAL TUMORS

The variety of benign tumors of the esophagus which are sufficiently large to produce clinical symptoms has provided little experience for clinicians and roentgenologists in diagnosis. There are, however, fairly good criteria for the diagnosis of benign esophageal tumors which can often make possible an accurate preoperative diagnosis.

Vinson[2] in 1926 stated that among approximately 4,000 patients complaining of dysphagia examined in the Mayo Clinic, benign tumor of the esophagus was found in only 3. In 1944 Moersch and Harrington[3] found 15 benign esophageal tumors among 11,000 patients complaining of dysphagia. These authors reported further that a review of 7,459 post-mortem examinations at the Mayo Clinic revealed 44 benign tumors of the esophagus. There were 32 leiomyomas among these 44 cases of incidentally found benign tumors in patients who had no esophageal difficulty in life. Shafer and Kittle[4] stated that in 6,001 post-mortem examinations at the University of Chicago Hospitals, 11 benign esophageal tumors were found. A great variety of benign tumors of the esophagus have been reported such as polyps, lipomas, papillomas, neurofibromas, adenomas, myxofibromas, hemangiomas, osteochondromas, and leiomyomas. Most authors have found that the common type of benign tumor of the esophagus is a polyp but the experience of Moersch and Harrington places leiomyomas first in frequency. In addition, Patterson[5] in a review of benign neoplasms of the esophagus found 61 cases between the years 1717 and 1932. There were 6 myomas among these reported cases. Bryant[6] in 1905 reviewed the literature on myomas of the esophagus and collected 9 cases and reported 2 more. All of these were found at autopsy and in only 2 were the symptoms referable to the esophagus. Fogge[7] in 1874 reported a case of myoma of the esophagus in the *Transactions of the Pathological Society of London*. The lesion was found at autopsy and was the first case of its sort reported before that society. The tumor measured 2 by 1.25 by 1 inch and projected into the esophageal lumen. In spite of this there was no history of dysphagia.

Miller[8] in 1912 reviewed the literature and collected five cases of leiomyoma of the esophagus between the years 1868 and 1897. One of these cases had been reported in 1872 by Coates[9] and dysphagia was a prominent symptom in that patient.

The most common sites for leiomyoma of the esophagus are the upper and lower thirds. The distribution between these two areas is generally considered to be equal although Rose[10] found the tumor most common in the lower third.

Benign tumors of the esophagus are divided into two main groups, extramucosal and mucosal. Leiomyomas arise from the smooth muscle of the esophagus and are classified as extramucosal or intramural. The growth of these tumors is usually slow and since they are extramucosal esophageal obstruction is rarely produced until they become unusually large. The association of a diverticula and myoma of the esophagus was reported by Stewart[11] in 1931.

Coates noted the relative absence of fibrous tissue in myoma of the esophagus as compared with uterine myoma but attributed this to the normal amount

of fibrous tissue found in the uterus as compared with the muscular coat of the alimentary tract. The incidence of malignant change in these tumors is not known but probably bears the same relation to malignant transformation of smooth muscle tumors located elsewhere in the body. We were unable to find any case in which malignant change definitely occurred in a pre-existing benign myoma but it is difficult in many cases to be definitely sure that the tumor with which one is dealing does not have malignant characteristics. Howard[12] in 1902 reported the first case of myosarcoma of the esophagus. The histologic examination revealed a mixed-cell sarcoma apparently derived solely from the smooth muscle tissue of the esophagus. There was associated ulceration of the esophageal mucosa and metastasis to the stomach and regional lymph nodes. Pennes[13] in 1942 was able to find only five esophageal leiomyosarcomas in a study of the literature on the subject, to which he added one of his own.

LEIOMYOMA INVOLVING BOTH THE ESOPHAGUS AND STOMACH

A thorough search of the literature revealed only four cases of leiomyoma involving both the lower end of the esophagus and the upper portion of the stomach. Two of these were found incidentally at post-mortem examination, the first of which was reported by Milovanovie[14] in 1914. The patient was a 63-year-old man who at autopsy was found to have had a perforated peptic ulcer, bronchopneumonia, and malnutrition. At the junction of the esophagus and stomach was a bean-sized myoma and two other myomas the size of peas on either side of the larger one. The largest of the three tumors was located half in the esophagus and half in the cardia of the stomach. The microscopic report of the largest tumor confirmed its position. The very middle of the tumor corresponded with the transition between the mucous membrane of the esophagus and the mucosa of the stomach. The microscopic report of the tumor was typical of a leiomyoma.

The second case, reported by Miller, in which a large myoma involving the lower part of the esophagus and cardia of the stomach was found, occurred in a 20-year-old boy and was discovered at post-mortem examination. This tumor measured 6 by 2 by 5 inches but had produced no symptoms.

The third case was reported by Brock[15] in 1942. This was the first successful resection of the cardia and the lower end of the esophagus reported from the continent of Europe and, as far as the author knew, the first of its kind from Great Britian. This leiomyoma involving the lower end of the esophagus and cardia was removed through a combined thoracoabdominal approach with an intrathoracic esophagogastrostomy. The tumor presented the typical picture of a benign smooth muscle tumor with simple ulceration of the overlying mucosa on the gastric side.

The fourth case was reported by Harrington and Moersch[16] in 1944. The patient was a 56-year-old woman who, at operation, was found to have a large leiomyoma of the lower part of the esophagus and cardia extending through and enlarging the esophageal hiatus. The esophagus was partially obstructed at the cardia. The greater portion of the tumor was situated in the

posterior mediastinum. The tumor was removed through an abdominal approach. An incision was made in the esophagus and stomach excising the tumor and the opening thus made was closed with interrupted silk sutures. These authors reported a second case of leiomyoma involving the lower five inches of the esophagus extending down to the cardia of the stomach but not involving it. This was removed through a transthoracic approach, and an intrathoracic esophagogastrostomy was performed. The patient died on the fourth postoperative day from bilateral bronchopneumonia.

DIAGNOSIS OF LEIOMYOMA OF THE ESOPHAGUS

The clinical manifestations and symptoms of all neoplasms of the esophagus are practically the same. The differential diagnosis cannot be made from carcinoma on the basis of symptoms alone but, as a rule, dysphagia is a more outstanding early manifestation of cancer of the esophagus and progresses more rapidly than in the case of benign tumors. Myomas of the esophagus may exist for years and attain huge size before symptoms become manifest. The most common symptom of these tumors is, of course, dysphagia. The first instance in which a leiomyoma produced symptoms referable to the esophagus was reported by Coates in 1871 and was found in the case of a 61-year-old man with symptoms of esophageal obstruction who died from inanition. At autopsy a large pedunculated tumor was found attached to the esophagus six and three-quarters inches below the glottis and extending to the cardiac orifice of the stomach. Microscopically the tumor was made up of spindle cells with a small amount of connective tissue.

A large leiomyoma of the esophagus and cardia of the stomach was reported by Miller. There were no symptoms referable to this esophageal tumor. Although these tumors are slow growing, they may produce obstruction resulting in marked dysphagia, nausea, and regurgitation of food. Symptoms are frequently intermittent because of the associated esophageal spasm. Pedunculated tumors may be regurgitated into the mouth as in the case reported by Moersch and Harrington or into the larynx causing hoarseness, paroxysmal cough, and intermittent obstruction of the larynx with dyspnea.

Tumors situated in the lower end of the esophagus give rise to epigastric discomfort. There may be an intermittent retrosternal sensation of dull pain or an aching sensation often aggravated by lying down. In those instances with tumors in which ulceration of the underlying mucous membrane has occurred, epigastric pain may be related to meals or there may be regurgitation of gastric fluid sometimes tinged with blood. Anorexia, nausea, weight loss, and occasional vomiting of rather large amounts of fluid due to dilatation of the esophagus similar to the situation found in achalasia are other symptoms which may be encountered.

Examination of the esophagus roentgenologically is necessary first in determining the presence and location of the growth. A definite histologic diagnosis can be established only by esophagoscopy and biopsy, although at times it may be difficult and inadvisable to obtain such specimens because of the necessity of penetrating the normal esophageal mucous membrane which overlies

these tumors. Patterson stated that Sommer in 1923 reported the only case in which a diagnosis of benign tumor was made roentgenographically. In this case the tumor was lobulated and the diagnosis was based on the appearance of the barium as it passed in the clefts between the lobules. Pape and Spitznagel[17] in 1931 recognized that a diagnosis of myoma of the esophagus was possible by roentgenologic means. The smaller myomas differ from carcinoma by absence of infiltration of the wall and the smooth contour of the mucosa. Large polypoid myomas can be recognized by the fact that the contrast medium flows around them, the continuous band of the contrast shadow being split while it stays constant and continuous in the case of a substernal goiter which may displace it. In carcinoma of the esophagus usually only one fixed, narrow canal is observed. Harper and Tisceno[18] in 1945 reported a case of intrinsic extramucosal tumor (leiomyoma) of the esophagus verified by operation and described the roentgenologic characteristic features of these tumors in detail. The important diagnostic features in differentiating benign extramucosal tumors from carcinomatous deformities are few but careful observation may lead to the correct diagnosis. The presence of a bulky and mobile soft tissue mass attached to the deformed esophageal area and more or less bulging into the mediastinum is characteristic of benign tumor and quite unlike the elongated fusiform soft tissue density ensheathing a stenosing carcinomatous filling defect. Intrinsic extramucosal benign tumors additionally have the following characteristics: Dilatation of the walls or bulging of one wall at the level of and opposite the affected segment may be observed. Other findings include absence of undermining margins, smooth margins of the forklike appearance of the barium, variations of the shape and dimensions of the filling defect, absence of actual obstruction, the presence of a smooth variable mold effect, the absence of any erosion of the mucosal covering in the tumor, preservation of the normal folds in the immediate vicinity of the filling defect, and the observation of a barium ring or "ring sign." The probability of establishing a correct diagnosis of myoma of the esophagus by roentgenologic means is fairly good, nevertheless, the final diagnosis can be definitely established only by esophagoscopy and biopsy.

We have recently resected a leiomyoma involving the esophagus and cardiac end of the stomach by the transthoracic route and a detailed case report follows. In so far as we are able to determine, this is the fifth reported case in which a leiomyoma of the esophagus and cardia of the stomach has been found and the third resected. In the case of the patient reported by Brock, resection was performed through a combined thoracoabdominal approach. Moersch and Harrington's patient had the lesion successfully removed entirely by the transabdominal route. In the patient to be reported here, transthoracic esophagogastrectomy was performed.

CASE REPORT

A 56-year-old housewife was seen first at the Boston Dispensary and applied to the clinic because of abdominal pain of three days' duration. About five months before, anorexia and nausea accompanied by attacks of dizziness had been experienced. She had lost fifteen pounds in weight during this time. There was never any vomiting and at no time did she

complain of dysphagia. Three days prior to admission the patient complained of generalized, persistent, mild abdominal pain. There was no radiation of this pain nor was it related to eating. Bowel movements had been regular and stools were normal color.

The past history revealed that twenty-five years previously she had suffered from "indigestion" for which gastric lavage and various powders had been prescribed. Twenty-two years before, a tumor had been removed from the uterus. Twenty years previously a cholecystectomy had been performed.

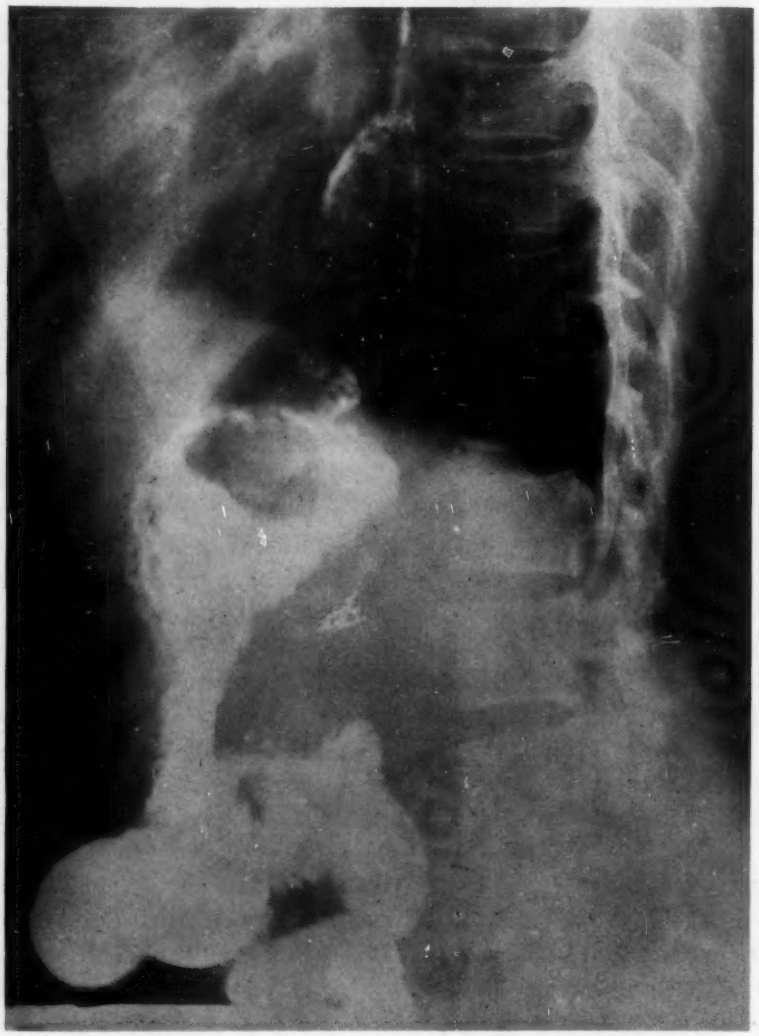

Fig. 1.—Lateral roentgenogram showing involvement of the lower esophagus and cardia of the stomach by a tumor which was thought to be a carcinoma.

The physical examination of the abdomen was not remarkable except for moderate tenderness on palpation of the midepigastric region. The red blood cell count was found to be 3.64 million per c.mm. of blood and the hemoglobin value 74 per cent.

Roentgenologic examination of the upper gastrointestinal tract revealed an irregularity of the lower end of the esophagus and, on several of the films, a suggestion of a filling defect within the lumen. The flow of barium was temporarily obstructed at the cardiac orifice and the lower end ballooned out with barium and air. The walls appeared distensible in this region. In the stomach a definite large mass was visualized in the cardia, which was polypoid in nature. There was some fixation and irregularity of the walls along the lesser curvature

side. A re-examination two weeks later revealed a nodular mass in the fundus with multiple nodules extending to the lower end of the esophagus for a distance of 6 to 8 cm. A diagnosis of cancer of the cardiac end of the stomach involving the lower end of the esophagus was made.

The patient was prepared for operation with blood transfusions, gastric lavage, and general supportive therapy. Operation was performed using gas-oxygen-ether administered by endotracheal tube. The patient was operated upon in the prone position and posterolateral thoracotomy performed with resection of the left eighth rib. In addition, the seventh and ninth ribs were divided. The phrenic nerve was crushed. A large smooth firm tumor was palpated within the two lower inches of the esophagus and was found to extend into the stomach. The diaphragm was opened and the stomach exposed. The lower portion of the

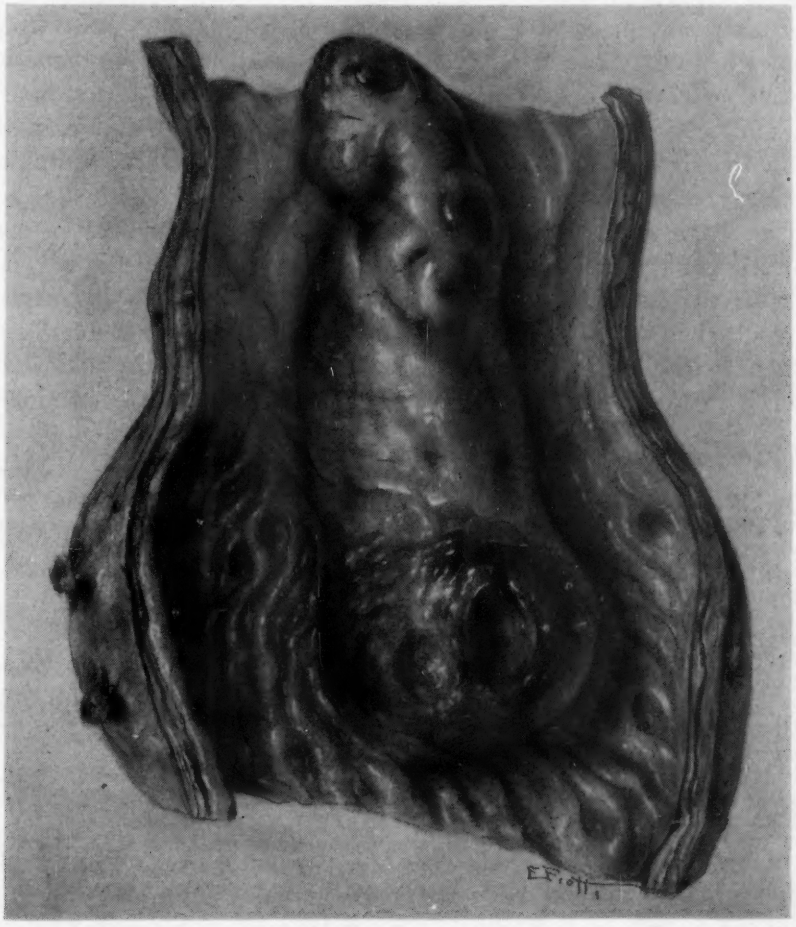

Fig. 2.—Artist's drawing of the resected esophagus and stomach showing the large leiomyoma involving both organs. Note the ulceration of the tumor on the gastric side.

esophagus and cardiac end of the stomach were then excised above and below the tumor mass in the usual manner. An incidental splenectomy was performed. The esophagogastric anastomosis was made on the posterior wall of the stomach, a more convenient placement when the patient is in the prone position. Catheter water-sealed drainage of the thoracic cavity was employed for forty-eight hours. The postoperative course of this patient was quite uneventful except for a moderate degree of discomfort along the line of incision. The patient ate without difficulty and was discharged on the thirty-eighth hospital day. A follow-up roentgenologic examination six months later revealed good function at the intrathoracic esophagogastrostomy.

The specimen was described as follows: Bulging into the lumen of the esophagus and the cardiac end of the stomach was a firm, rubbery, fusiform and grossly nodular tumor mass which appeared everywhere to be covered with mucosa except at its inferior end where there was an ulceration in the anterior surface measuring 1 cm. in diameter and .5 cm. in depth. At the proximal portion several small secondary nodules were attached to the main mass. Sections through the tumor mass revealed it to be well encapsulated and showed a rubbery, pale gray, finely trabeculated and finely whorled surface. The tumor mass measured 10 cm. in length and had an average diameter of 3.0 cm. The microscopic examination revealed a leiomyoma of the wall of the esophagus and stomach with ulceration of the gastric mucosa at two points.

In Fig. 1 the roentgenograms taken preoperatively showing the tumor involving both the stomach and the esophagus may be seen. In retrospect the diagnosis of benign tumor, possibly leiomyoma, could have been made if it were known that leiomyomas sometimes involve both of these structures at their junction and while carcinoma is by far the most common lesion in this area, the fact that benign tumors do exist here has been our reason for calling attention to this unusual lesion.

In Fig. 2 the artist's drawing of the resected specimen may be seen. The characteristic ulceration of the tumor through the gastric mucosa which so often results in massive hemorrhage from leiomyoma of the stomach, in the case of our patient resulted in some chronic blood loss with moderate anemia. The absence of dysphagia with so large a growth at this area can be easily understood since the tumor is intramuscular and does not constrict the esophageal mucosa.

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AN IN VIVO METHOD FOR EVALUATION OF DETERGENTS AND GERMICIDES

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THERE have been many techniques for the evaluation of skin detergents and germicides. That of Price[1] has contributed greatly to the knowledge of the bacteriology of the skin and is an effective method for determining the relative efficiency of germicides. Because there are several major variables in this technique which are uncontrolled and because at least seven days must elapse between determinations for the numerical recovery of the bacterial flora on a subject's skin, experiments are necessarily protracted and strictly comparable determinations are impossible.

The technique to be described was intended to permit multiple determinations on contiguous areas of human skin so that various agents can be tested on the same skin on the same day.

An apparatus, Fig. 1, was designed and built to standardize the various mechanical factors involved in scrubbing techniques. This device isolates adequate areas of skin and scrubs it at a constant rate with a specially designed brush pressed against the skin by a constant force. The machine has three elements: a mechanical reciprocating scrubber, a stable brush, and a vacuum seal to isolate and hold the skin against the brush.

The reciprocating scrubber is driven by a gear reduction motor at 30 strokes per minute. Briefly, it consists of a rocker shaft mounted on a balanced arm. At the pivoted end of the balanced arm, the rocker shaft is actuated by a hinged rocker arm bearing a slide block which is driven by a crank mounted on the motor shaft. At the opposite end, the rocker shaft carries a rocker arm which supports a detachable brush. A small tray at this end of the balanced arm accommodates the weights used to load the brush.

The brush§ was designed to withstand repeated (300 times) sterilization by exposure to saturated steam at 121° C. for thirty minutes without a significant change in brushing characteristics. The nonwetting Nylon bristles are 0.25 mm. on centers. Two rows of tufts set in a heat-resistant plastic back were used.

The vacuum seal is created in a space around a square aperture, 4 by 4 cm., in the concave bottom of a stainless steel pan. The edges of the aperture are bent downward 0.5 mm. The radius of the concavity is of the same length as

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§No. 157, Prophylactic Brush Company, Florence, Mass.

the rocker arm and brush assembly so that the entire skin area is scrubbed uniformly and the bristles rub on the pan at either end of the stroke to divest themselves of organisms and detritus. The seal is made by mounting a second aperture, 4.2 cm. square, 1 mm. below the convex surface of the pan. Negative pressure applied to the space between the apertures effectively seals the skin to the pan. The entire pan can be detached for sterilization. Stainless steel was used because it has minimal oligodynamic action. An adjustable rest faced with sponge rubber is mounted beneath the aperture to support the hand. The rocker arm and brackets that support it are long enough to extend over the back of a prone subject.

TECHNIQUE

The pan and brush are sterilized in saturated steam at 121° C. for thirty minutes. The surface of the remainder of the apparatus is washed with 0.1

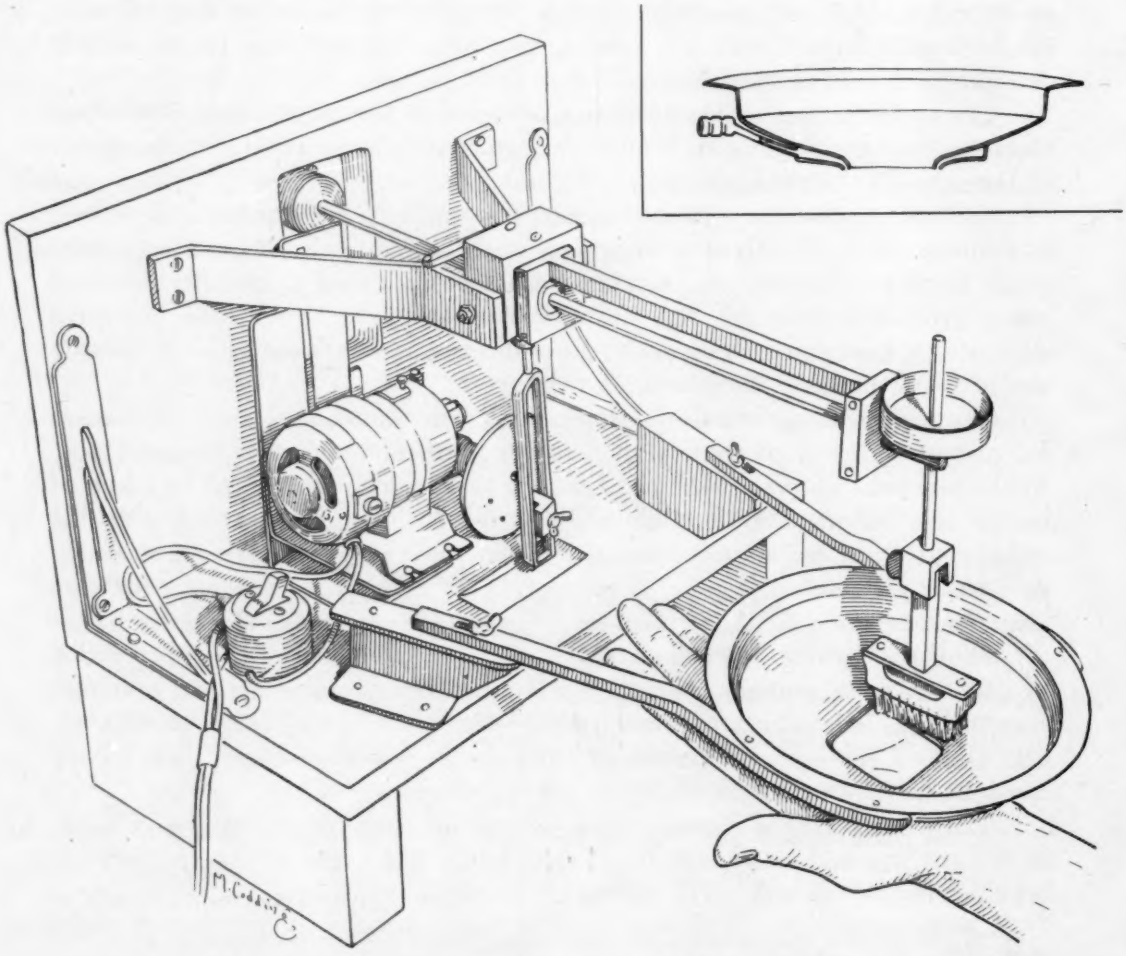

Fig. 1.—Mechanical scrubber for evaluating detergents and germicides. A gear reduction motor drives a weighted Nylon bristle brush through a slide block and rocker arm assembly. An area of skin is isolated by negative pressure applied about the periphery of an aperture (cross sectional view in insert) in a stainless steel pan.

per cent aqueous Zephiran and covered with a Pliofilm hood prior to each experiment to control air-borne contamination. The subjects are requested not to wash their hands for four hours before the test and are known not to have contacted germicidal solutions for four days. In this study the subjects were chosen at random from volunteers.

The hand is adjusted on the rest so that the flat mid-portion of the palm is in firm contact with the sealing chamber of the scrubbing pan and 250 mm. Hg negative pressure is applied to isolate the test area of skin. Five cubic centimeters of sterile distilled water are run on the test area of the skin. The brush is fixed in position and the skin is scrubbed with 110 Gm. pressure on the brush for ten complete reciprocating strokes. The water is aspirated with a sterile suction tip into a sterile test tube. Care is taken to remove as much water as possible. The same brush is used for subsequent test periods using similar amounts of distilled water and ten strokes. This process is repeated thirty times. On the thirty-first group of ten strokes, the pressure on the brush is made as hard as the subject can bear without discomfort. Thus, any remaining organisms which can be removed by increased pressure are detected. There were no cases in this study in which a variation beyond the predicted number was obtained, so that it appeared that at this point on the control curve there were few additional organisms available for removal. The complete series of scrubs was sufficiently traumatic to abrade soft skin such as that on either side of the midline of the back.

The technique for the evaluation of germicides is identical to that of the control curve except that the substance to be tested is introduced on the skin surface after the initial period of ten strokes with water, that is, at the second point of the curve. A new sterile brush is fixed and the hand scrubbed for ten strokes. The germicide then is aspirated, the brush removed from the pan, and, while the skin is rubbed with a cotton pledget, it is rinsed three times with 5 c.c. sterile water to remove the test substance. This simple washing with water and friction after an initial scrub with water removes an insignificant number of organisms. The original brush is then replaced and the scrub continued as in the control series, using 5 c.c. of water and ten strokes of the brush. The repeated scrubbing with fresh water further dilutes residual germicide beyond bacteriostatic levels and should break up any film the germicide may precipitate in the skin. Immediately following completion of the scrub, the contents of each tube are transferred to a sterile Petri dish and pour plates are made using Difco beef agar. Colony counts are made after twenty-four and forty-eight hours of incubation at 37.5° C. using a Quebec colony counter.

RESULTS

Control curves were obtained using sterile water. Colonies of "spreading" organisms on the plates caused a number of experiments to be discarded because it was impossible to count the colonies. Experiments yielding an initial count of below 500 colonies were likewise discarded because the paucity of organisms made these seem less reliable although, when plotted, the same general type of curve was obtained.

Nineteen experiments were finally accepted. These showed an average of 2,320 colonies on the initial ten strokes. When the curve of the average control experiment was plotted in conventional manner, number of bacteria removed against number of brush strokes, it corresponded to that of a rectangular hyperbola following the general formula of $y = f\ (\times)^{-1}$ and closely approximated the calculated curve, Fig. 2. Thus, the second ten strokes should yield one-half, and the third ten strokes one-third the number removed by the first ten. It should be noted that this is not a simple dilution curve. Cumulative totals of organisms removed in successive intervals of scrubbing, a concept introduced by

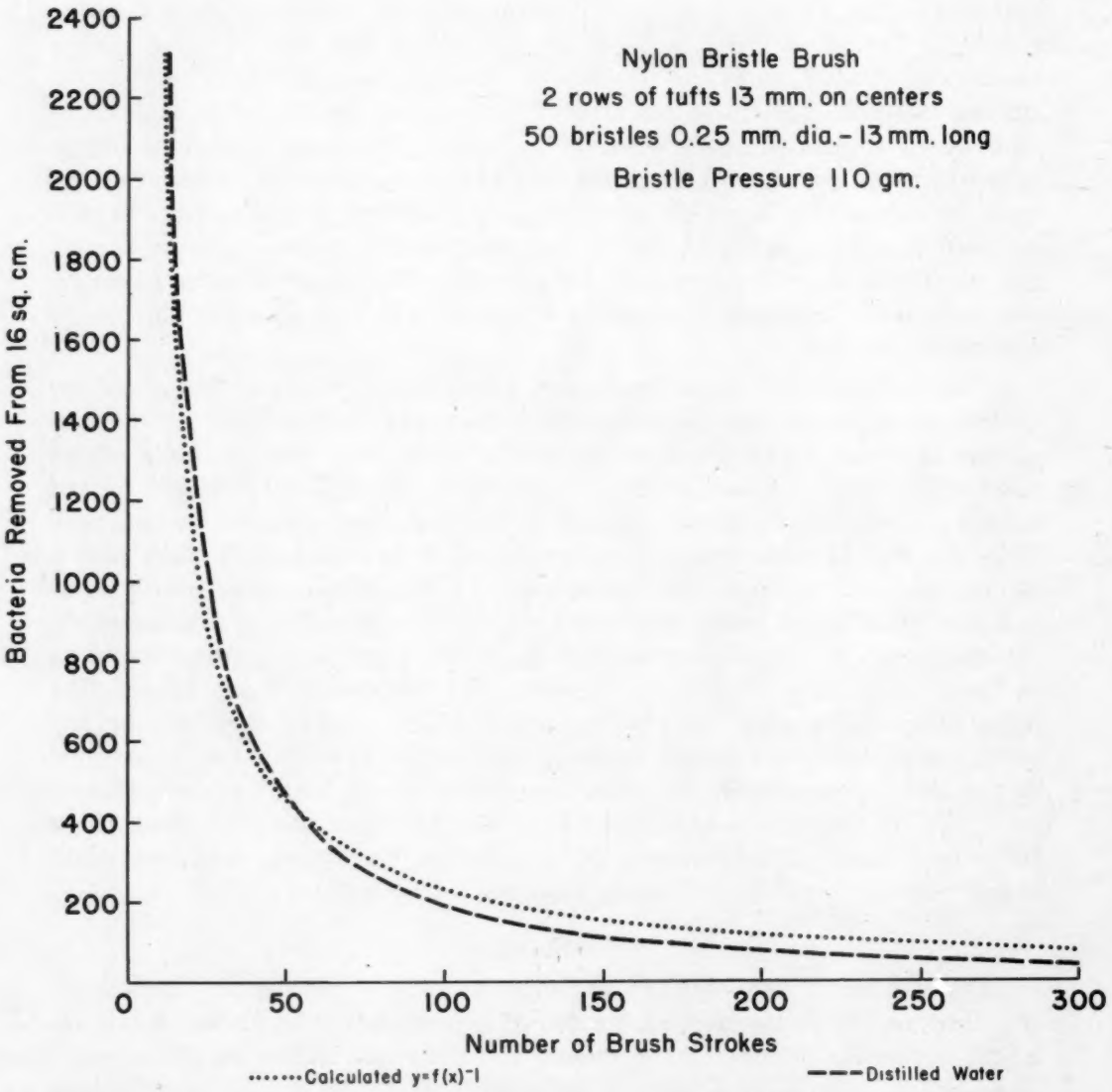

Fig. 2.—The effect of mechanical scrubbing. The distilled water, or control curve, demonstrates the effect of mechanical scrubbing alone. The curve expresses the average of nineteen experiments. It corresponds with that of the rectangular hyperbola $y = f\ (x)^{-1}$.

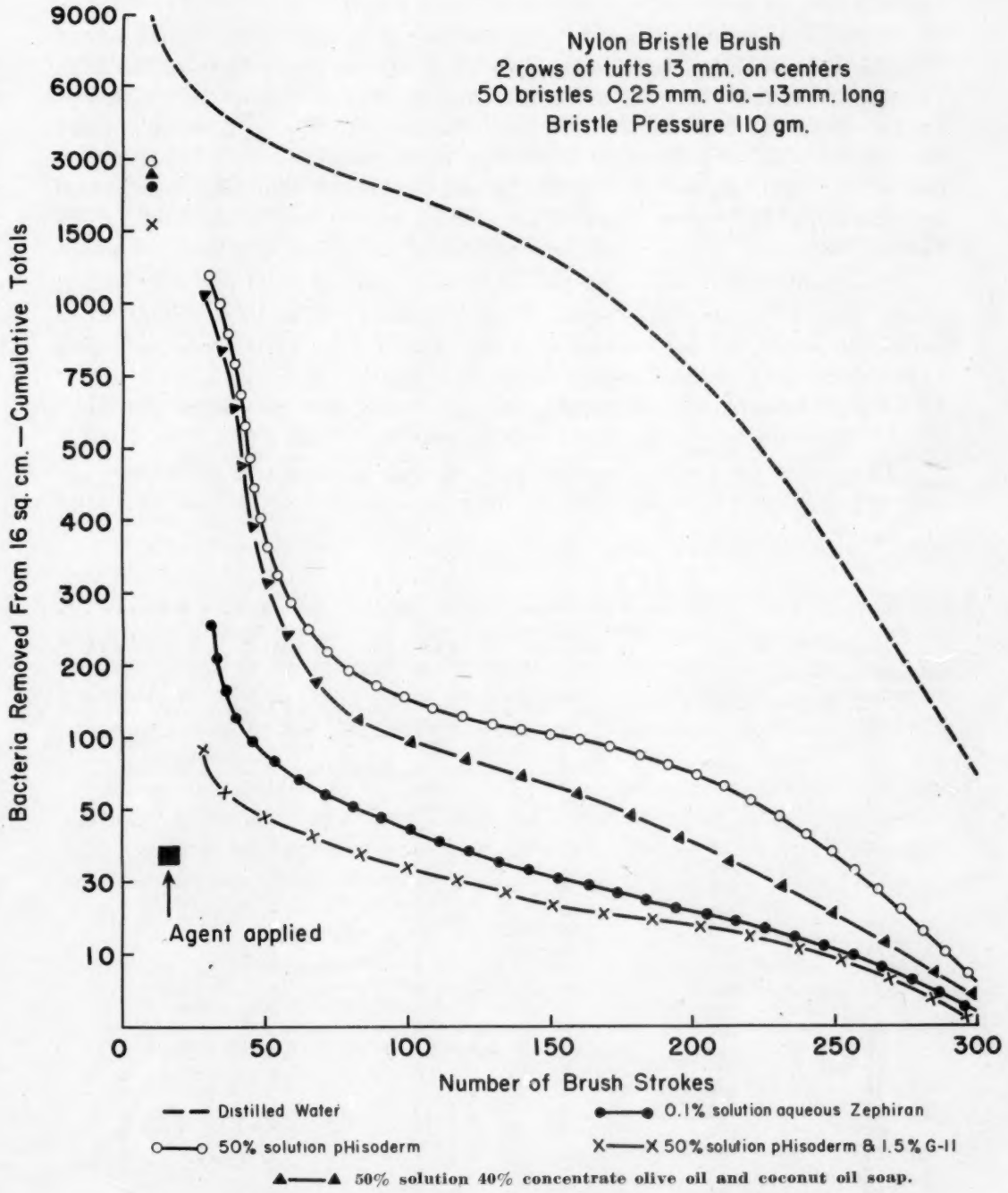

Fig. 3.—The comparative disinfecting effect of scrubbing, detergents, and germicides. The distilled water curve is made from the same data as Fig. 2, plotted cumulatively rather than in conventional fashion. The total counts for the other agents are given at ten brush strokes. The second period of ten strokes is that used to apply the agent. The third period, therefore, represents the total number of organisms removed following the application of the agent under study. The drop from the control curve portrays its relative effectiveness.

Price,[1] when plotted against the number of strokes applied, form a curve which portrays best the contrasts between experiments, Fig. 3.

Germicides or detergents were evaluated by applying them during the second interval of scrubbing. Ten strokes were thus used to apply them to the skin. The agent was then removed by suction and by dilution. Since only a film of fluid covering the skin was left each time, the triple rinsing with water reduced the concentration of each agent well below bacteriostatic levels. The effectiveness of the agent applied during the second interval of scrubbing was judged by comparing differences between the control curves and those obtained by plotting the counts of the subsequent periods of scrubbing with distilled water.

The agents tested were a 40 per cent concentrate of equal parts of coconut oil and olive oil soaps diluted equal parts with water; pHisoderm, diluted equal parts with water; 0.1 per cent aqueous Zephiran N.N.R.; pHisoderm containing 3 per cent G-11, diluted equal parts with water. G-11 is 2,2′-dihydroxy-3,5,6-3′,5′,6′ hexachlorodiphenylmethane, a promising new cutaneous germicidal agent.[2] A comparison of the result may be seen from Table I and Figs. 2 and 3.

The curves for ten scrubs each with coconut oil soap and pHisoderm are extremely similar. Both had average initial counts of close to 1700, and after

TABLE I

AGENT	CONTROL	COCONUT AND OLIVE OIL SOAP 20 PER CENT	PHISODERM #44 WATER āā	ZEPHIRAN 0.1 PER CENT AQUEOUS	PHISODERM AND 3 PER CENT G-11 WATER āā
NUMBER OF EXPERIMENTS	19	10	10	10	10
SCRUB PERIOD	AVERAGE COLONY COUNTS				
1	2320	1703	1665	2502	1568
2	1410	agent applied			
3	802	460	649	131	7
4	605	275	185	28	5
5	496	118	99	15	4
6	355	67	46	1	4
7	285	23	29	8	4
8	282	18	23	5	2
9	244	15	21	4	3
10	208	11	13	4	2
11	204	9	13	3	3
12	130	8	8	3	2
13	165	6	7	2	2
14	140	8	7	2	1
15	124	6	8	3	1
16	116	5	6	2	1
17	120	6	6	2	2
18	116	4	6	2	2
19	76	4	7	3	2
20	100	4	8	2	2
21	80	3	7	1	2
22	71	3	9	1	1
23	64	3	8	2	0.5
24	60	3	6	3	2
25	68	4	8	3	2
26	52	4	8	1	2
27	48	3	5	1	2
28	64	3	4	1	2
29	53	2	5	1	2
30	44	2	5	1	1

100 strokes, tube 9, had reached colony counts approaching ten in contrast to the control of 244.

Using Zephiran, however, the fall in the average number of organisms was much more rapid from an initial count of 2,500 to 130 organisms on the first ten strokes. Very few organisms could be removed after the ninth tube with an average of only two colonies per tube after that point and the majority of tubes were sterile. The total average number of organisms after the use of 0.1 per cent aqueous Zephiran for thirty seconds and ten strokes was 237 in contrast to 5,172 with water, 1,075 with coconut oil soap, and 1,207 with pHisoderm.

The results with pHisoderm and 3 per cent G-11 were even more striking. This agent was diluted with an equal amount of water before use. The initial count was 1,500 and the first tube after its use showed only seven colonies. Subsequent tubes showed further reduction and the total number of organisms removed by the water after its use averaged 65.

CONCLUSIONS

1. A technique is described which has been elaborated to permit multiple determinations of the bacterial flora of the human skin under standardized mechanical conditions.

2. The effectiveness of various agents is strikingly portrayed by the cumulative plotting of the data obtained.

3. The agents investigated are primarily detergents. The conventional practice is to use soap and pHisoderm for longer periods of time than employed in these experiments, yet comparable rates of removal of bacteria are detectable under the conditions employed. Zephiran exhibits marked germicidal properties on more prolonged exposure than the 60 seconds' maximal exposure possible in this technique.

4. Recent studies, to be elaborated in a subsequent report, indicate that pHisoderm fortified with G-11 displayed the most rapid disinfecting action. This combination appears to be more effective than any detergent commonly employed for the preoperative preparation of skin.

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CHOLEDOCHOTOMY

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CHOLEDOCHOTOMY is an important supplementary procedure of cholecystectomy, whether it be done at the time the gall bladder is removed or whether the later symptoms of the patient necessitate exploration of the common duct at a future date. At the time of every cholecystectomy the question arises before most surgeons as to whether or not the common bile duct should be opened and explored. To some, this question never arises—the common bile duct is explored in every instance. Certainly the criteria for choledochotomy are at variance with different surgeons, but most recognize certain factors which demand extrahepatic biliary exploration. In an attempt to understand better the dangers of this operative procedure, as well as to establish the criteria for choledochotomy more definitely, where this operation is not practiced routinely, we have reviewed 439 consecutive cases in which the common bile duct was opened and explored. This study encompasses a twelve-year period from July, 1934, to July, 1946. We have also enumerated the complications that seem peculiar to this operation. In each patient in whom the common bile duct was opened the duct was drained to the outside by means of a catheter or T tube. We have attempted to evaluate the length of time drainage should be employed, once it is instituted. This study has established certain beliefs which are worthy of note. We are impressed that choledochotomy is not the benign and uncomplicated procedure which it is sometimes believed to be.

In any discussion of choledochotomy, cholecystectomy cannot be excluded because of the close anatomic relations of the gall bladder and the common duct. The same dangers of cholecystectomy are ever present when the common duct is explored. Daseler and associates[2] have recently published their classic study of the anatomic variations of the hepatic pedicle. Accidents at operation, from sectioning the portal vein or hepatic artery, may result in a tragic ending to a "simple cholecystectomy." Or, injury to the extrahepatic ducts may result in death or a stricture of the duct, the result of which requires no emphasis. Certainly, too strong an emphasis cannot be placed upon a knowledge of the "anomalies" and the usual anatomy of the hepatic pedicle. Exact knowledge of the normal anatomy and its variations must be demanded of every surgeon before he operates upon the biliary system. Fig. 1 reflects well the improvements in technique and our greater knowledge of the preoperative and postoperative requirements of these patients. Because of the striking difference in mortality rate during this relatively short period, the factors which we have considered effective in reducing mortality should be mentioned.

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Vitamin K.—It is well known that patients who are jaundiced or who have experienced repeated episodes of jaundice may have a prolonged prothrombin time. If the patient is not jaundiced, the possibility of prothrombin deficiency may be overlooked. It should be remembered that prothrombin deficiency may be due to any one of several factors—inadequate nutritional intake, absence of bile and hence inadequate absorption of vitamin K, or inadequate synthesis of prothrombin by a poorly functioning liver. It is well to emphasize that patients with an increased prothrombin time should have the operation deferred until the deficiency has been corrected. A prolonged preoperative period of preparation along with large doses of vitamin K parenterally are often necessary to correct this deficit.

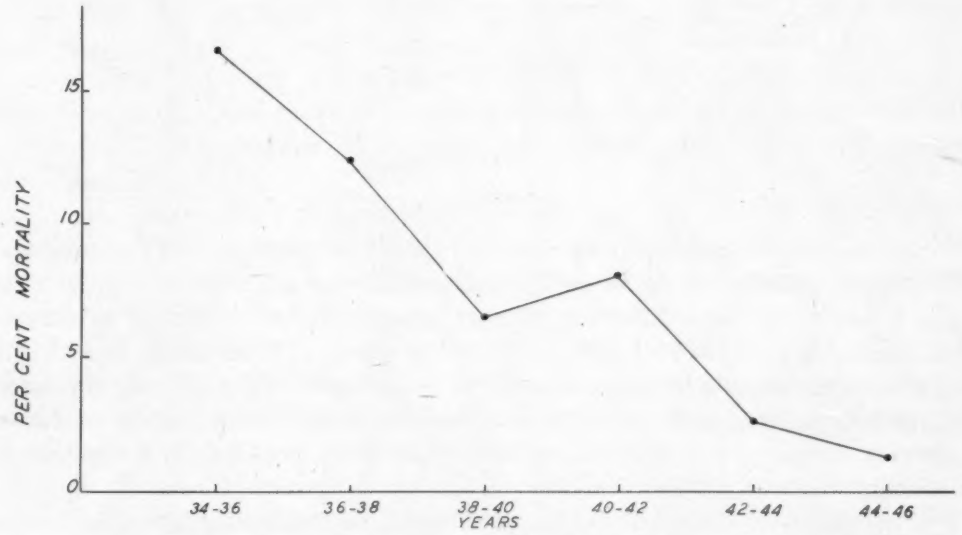

Fig. 1.—Mortality rates in choledochotomy (439 cases, 1934 to 1946).

Antibiotics.—Many times patients who have common duct obstruction have a concomitant cholangitis and hepatitis. It is only logical that the antibiotics would be beneficial.

Electrolyte and Fluid Balance.—An imbalance in either fluids or electrolytes may be overlooked in the preoperative period. This is a particularly important problem in the postoperative period when the patient has an external biliary fistula.

Nutrition.—Many of these patients have lost considerable amounts of weight because of inadequate food intake. Their admission of weight loss should be a reminder of a possible deficiency in proteins and vitamins. Certainly weight loss demands investigation with steps to correct the deficiencies that exist.

Blood.—The correction of a secondary anemia in the preoperative period, as well as the use of adequate amounts of whole blood at the time that it is lost at operation, has been shown to be of extreme importance.

With these therapeutic aids and the present low mortality rate it would seem that any discussion regarding criteria for opening the common bile duct is

inconsequential. However, a statistically greater morbidity and mortality is associated with choledochotomy when this procedure is added to cholecystectomy. We have encountered certain complications which are directly related to the fact that the common duct was opened. And, although wound infection and subphrenic abscess are not unique following choledochotomy, we think the incidence is higher than it is in cholecystectomy alone. Choledochotomy certainly may be a factor in their occurrence. During the period of this study, from 1934 to 1946, the following complications (Table I) have occurred (excluding those cases in which death occurred).

TABLE I. COMPLICATIONS FOLLOWING CHOLEDOCHOTOMY IN 439 CASES

COMPLICATIONS	NUMBER
Retained calculi	26
Stricture	2
T tube broken in removal	2
Duodenal fistula	1
Subhepatic bile abscess	1
Subphrenic abscess	6
Wound infection	32
Total	70 (15.9%)

These seventy complications occurred in 439 patients so that the total morbidity from choledochotomy in this period was 15.9 per cent. If one contends that wound infection and subphrenic abscess are not uniquely related to common duct exploration, there still remain thirty-four cases (7.2 per cent) in which the complications seem definitely related to choledochotomy. These percentage figures lend support to the opinion that choledochotomy should not be performed routinely but should be carried out only when there is a definite indication for so doing.

The patients' historical background and the findings at operation, which formed the basis for our decision to open and explore the extrahepatic biliary system, are listed in Table II. The presence of any one of these criteria demands common duct exploration.

TABLE II. CRITERIA FOR COMMON DUCT EXPLORATION

1. Palpable stone in the hepatic or common bile ducts
2. Jaundice
   (a) Present on admission to the hospital
   (b) Recent (within 3 months)
3. Dilatation of the duct or thickening of the periductal structures
4. Clinical evidence of cholangitis
5. Multiple small stones in the gall bladder
6. Thickening or induration of the head of the pancreas
7. Biliary colic without stones in gall bladder

Certainly there is no disagreement regarding certain criteria for choledochotomy. The presence of a palpable stone is an obvious indication for duct exploration. The presence of jaundice at the time of operation or an unequivocal history of a recent episode of jaundice also demands duct exploration. The word "recent" is an ambiguous one. The arbitrary time is a difficult one to decide upon but it has seemed reasonable to set an interval of three or four months of

freedom from jaundice as a minimum. In this series of cases two and one-half months was the longest interval without jaundice, in those cases in which the duct was opened for "recent" jaundice and in which stones were found within the duct. If the patient has had partial or recurring obstruction as the cause of the jaundice, changes in the duct will also be present.

A thickened or dilated duct suggests that obstruction may be present; common duct exploration is then indicated. Clinical evidence of cholangitis, in which the patient has had recurring chills and fever, with or without jaundice, is also a well-accepted reason for biliary exploration and drainage.

Small stones in the gall bladder have always been a debatable criterion for duct exploration. The size of the stones must be considered in relation to the size of the cystic duct. If the stones are extremely small it is always possible for one or more of these to have passed through even a small cystic duct. Such a small stone need not indicate its presence by jaundice; 37 per cent of the stones removed from the ducts of the patients in this series were not associated with jaundice. In only one case in this group of patients, in which the common duct was explored solely because of the presence of small stones in the gall bladder, was a stone found.

A small contracted gall bladder is sometimes referred to as an indication for common duct exploration. However, unless this finding has been associated with other more obvious indications for common duct exploration, none of the patients in this series had duct calculi upon duct exploration.

In this series of patients calculi were found in 190 instances. In only 92 cases (48 per cent) did the surgeon record his ability to palpate stones before opening the duct. In 38 instances the findings on palpation were not recorded. In 61 cases (32 per cent) the stone could not be palpated. This, of course, is excellent evidence that certain criteria for choledochotomy must be established so that stones, when not palpable, will not be missed. We have tabulated (Table III) the reasons for opening the common bile ducts in those patients in whom stones could not be palpated at the time of operation, but from whom stones were removed from the common duct.

TABLE III. INDICATIONS FOR CHOLEDOCHOTOMY IN NONPALPABLE CALCULI (61 CASES)

INDICATIONS	NUMBER
Jaundice	4
Jaundice, dilated duct	14
Jaundice, dilated, thickened duct	4
Jaundice, small stones in gall bladder	6
Jaundice, dilated duct, small stones in gall bladder	11
Dilated duct	3
Dilated, thickened duct	2
Dilated duct, small stones in gall bladder	4
Dilated, thickened duct, small stones in gall bladder	1
Thick duct, small stones in gall bladder, recent jaundice	1
Dilated duct, recent jaundice	4
Recent jaundice	1
Recent jaundice, small stones in gall bladder	1
Small stones in gall bladder	1
Indurated, thickened head of pancreas, dilated duct	1
Biliary colic without gall bladder stones	1
Choledochoduodenal fistula	1
No reason given	1
Total	61

The presence of a spontaneous choledochoduodenal fistula is an uncommon finding at operation and is seldom included in a listing of the more common indicators for duct exploration because of the rarity.

Whenever the common duct is opened and explored it has been drained routinely. If the duct is left completely patent at the conclusion of the operation, leakage may well not occur at the point of closure of the duct. However, it is entirely possible that a leak with the formation of a bile abscess or peritonitis may occur. This possibility is enhanced immeasurably if a residual calculus is present. It is often difficult to be certain that residual calculi do not remain, even after very careful exploration. Cholangiography at the time of operation does not always overcome this obstacle.[1]

During the twelve-year period under study, stones were found at the time of operation in 190 patients. In seventeen of these, subsequent cholangiograms showed the presence of a retained calculus. Eight calculi required removal at a second operation. At the same time 249 choledochotomies were performed in which stones were not found. Subsequent roentgen studies showed the presence of a common duct calculus in nine of these patients. Three of these patients required removal of the retained stone by operation. This is a total of 26 retained calculi in 439 choledochotomies (5.9 per cent).

This high incidence of retained calculi indicates the surgeon's difficulty in being certain that no stones are missed at the time of operation. The usual methods of common duct exploration were employed in all instances. Transduodenal removal of calculi was necessary in 18 of 190 cases of common duct stone. In only two of these cases did complications arise. In both instances only mild wound infections occurred.

The postoperative cholangiographic studies on five patients (Table IV) revealed one or more opaque shadows in the outline of the common duct, suggestive of residual calculi. In each instance the T tube was removed at the suggestion of the surgeon; the reason for this decision is no longer apparent. Recent information on each of these five patients indicates no residual symptoms of duct calculus. Only one patient had a single episode of jaundice following discharge from the hospital. No additional symptoms or recurrence of jaundice have occurred in this patient in a period of three and one-half years.

Several explanations can be offered for the excellent end results in these five patients. It is quite apparent that a single cholangiogram (two patients) offers no conclusive evidence of a residual calculus. In those patients upon whom repeated roentgenographic studies were carried out there seems good evidence of stone. We must presume that these have been discharged from the duct or

TABLE IV. RETAINED CALCULI

CALCULI	NUMBER
Removed at reoperation	11
Gone after irrigations	8
Present last x-ray	5
Present last x-ray—death after leaving hospital	2
Total	26

are still present but have failed to produce symptoms of obstruction. The latter course seems unlikely since all of these patients were operated upon from three and one-half to eight years ago. While it is possible for a calculus within the common duct to remain silent for this length of time, it seems improbable that such a course would be followed in all of these patients.

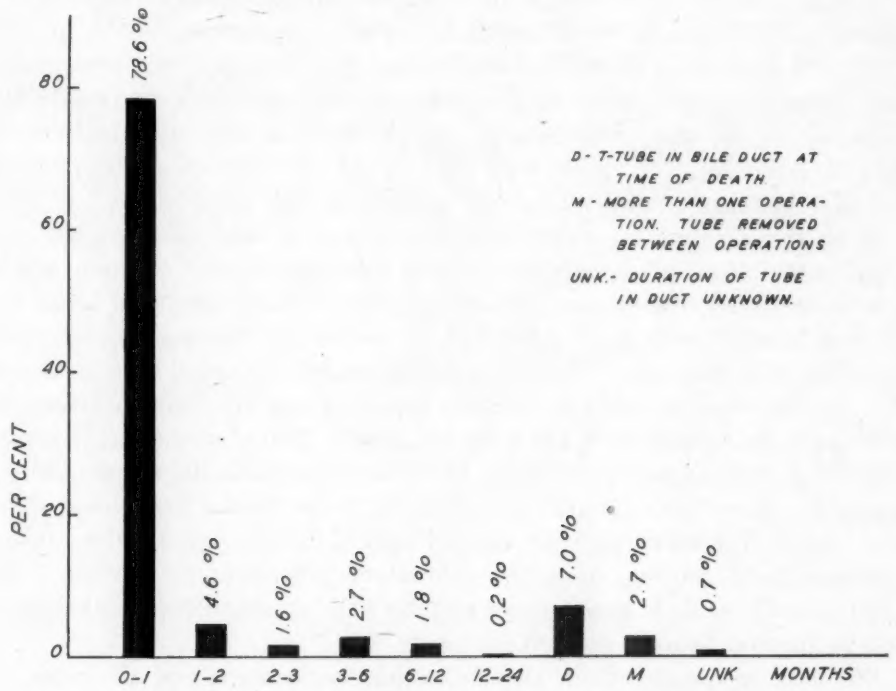

Fig. 2.—Duration of T tube or catheter in common bile duct.

With the high incidence of retained calculi some additional means of investigating the duct system at operation seems requisite. This need is answered in part by exploration of the biliary ducts by means of a cholangiogram at the time of operation and prior to closure of the abdominal wall. Such a procedure adds only a few extra minutes to the operation and may often insure a completely patent biliary system. The presence of a filling defect in the choledochogram is not unequivocal evidence of a retained calculus. Air bubbles, mucus, or debris may produce confusing defects and the diagnosis of a retained calculus is not entirely reliable from a single, and occasionally multiple, cholangiogram. In eight cases (Table IV) the roentgenographic evidence of obstruction disappeared postoperatively after irrigations of the duct system. Since a single cholangiogram is not complete evidence of a retained calculus, and if an obstructing defect is apparent, irrigations of the duct system are worthy of trial before resorting to a second operation.

Following exploration and drainage of the extrahepatic ducts, the surgeon must always decide the optimum time for withdrawal of this drainage tube (Fig. 2). After careful scrutiny of this group of patients, the following observations can be recorded:

1. When the duct is normal in appearance, slightly or moderately dilated or very slightly thickened, the catheter or T tube may be removed within eight to fourteen days following choledochotomy. Before withdrawal there must be cholangiographic evidence of freedom from obstruction, prompt spillage into the duodenum, and full visualization of the major hepatic radicles.

2. The presence of a catheter or T tube within the biliary ducts for as long as one to two years has not produced stricture or severe scarring.

3. In the presence of marked thickening and dilatation of the common bile ducts, it has been our policy to allow the catheter or T tube to remain in situ for two to six months, often longer. The patient is instructed to irrigate the tube with saline solution two to four times daily and is given an oral cholegogue which is to be taken as long as the tube remains within the duct.

With these observations in mind, it is proper to note that two patients developed a stricture, after exploration and drainage of the common bile duct, which necessitated reoperation. In one instance a tube, much too large for the duct, was inserted with some difficulty. It is obvious that necrosis of a portion of the duct wall may occur when it is stretched and distended by a large foreign body. In the other patient the common bile duct was accidentally transected at the time of cholecystectomy, anastomosed, and a T-tube splint left in place for two months. Subsequent obstruction by stricture necessitated reoperation. This instance has been instrumental in indicating to us that a transected duct, repaired over a T tube or catheter, should have that tube left in place for six to twelve months depending upon the amount of inflammatory reaction and scar present about the site of anastomosis and the preciseness with which the operator is able to approximate the severed duct ends.

We have concluded then, that following exploration and drainage of the common bile ducts, the T tube or catheter may be removed within the first two weeks provided the ductal lumen is adequate and unobstructed and that the walls of the duct are not markedly thickened. When there is evidence of marked choledochitis the drainage tube should be left in place, with frequent daily irrigations, for two to six months. If a stricture is present or anticipated, healing and contracture are expected and the tube splint should remain within the duct until these processes are complete. These simple observations have contributed greatly toward a satisfactory conclusion in the patients upon whom we have performed choledochostomy.

SUMMARY

Certain definite criteria should exist before the common bile duct is opened. These are:

1. Palpable stone in the hepatic or common bile ducts
2. Jaundice—on admission to the hospital or recent
3. Dilatation or thickening of the bile ducts
4. Clinical evidence of cholangitis
5. Small stones in the gall bladder
6. Thickening or induration of the head of the pancreas
7. Biliary colic without stones in gall bladder

The presence of any one of these criteria demands choledochotomy. A small contracted gall bladder is not considered as an indication for choledochotomy nor is a history of jaundice unless its occurrence has been recent.

The incidence of retained calculi in this group of patients is 5.9 per cent.

In all patients the common duct was drained through a T tube or catheter. The length of time the tube remained in situ depended upon the findings at operation. Conclusions, based upon the observations of the surgeon at operation, are made upon the length of time external drainage of the hepatic and common bile ducts should be carried out.

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MYOTONIA ACQUISITA DUE TO CHRONIC CALCULOUS CHOLECYSTITIS AND CURED BY CHOLECYSTECTOMY

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MYOTONIA acquisita is a rare disease of muscle which presents the outstanding features of increased muscular irritability and contractility associated with diminution in the power of relaxation. It constitutes a syndrome which includes the *myotonic disorder of movement* with stiffness, tension, and spasm in the voluntary muscles when movements are initiated, the *myotonic reaction* with normal mechanical and electrical excitability of the motor nerves, but an increased mechanical and electrical excitability of the muscles, and *muscular hypertrophy.*

There have now been described to our knowledge thirty-six cases of myotonia acquisita.[1, 2] These have all occurred in men patients except one. The one case occurring in a woman was reported by Nosik and Shannon[3] in 1942.

The acquired form (myotonia acquisita or Talma's disease) has been usually differentiated from the congenital form (myotonia congenita or Thomsen's disease) although these may be different chronologic manifestations of the same underlying pathologic process. The underlying pathogenesis is as yet not fully understood even though we know Talma's disease is not congenital in origin but usually develops in adult life following or during an infection or following trauma or intoxication. In fact, myotonia acquisita frequently, if not always, is secondary to some other disease entity. It has already been described to have occurred following trauma, dysentery, gastroenteritis, alcoholism, lead poisoning, tuberculosis, and typhoid fever. The disease tends to improve spontaneously or go on to complete recovery. Frequently, however, it is important to search for an underlying primary cause in the secondary form since removal of this factor may decrease the severity and length of morbidity of the myotonia such as is demonstrated in our case. Myotonia apparently followed chronic calculous cholecystitis with an associated chronic hepatitis and was cured after cholecystectomy, choledochostomy, and adequate follow-up treatment of the hepatitis in the case we are about to report.

CASE REPORT

The data up to 1942 on this patient are fully described in the report of Nosik and Shannon.[3] While at the Cleveland Clinic in 1942 she complained of cramping muscles and swelling of joints. She became aware for the first time of cramping pain in the right calf with radiation down to the foot in 1936, three months following a panhysterectomy for menorrhagia. The pain often awakened the patient during the night and was not related to exercise. Marked inversion and plantar flexion of the right foot frequently were associated with the severe pain. The other calf and both arms were similarly involved in pain. Fibrillary twitching of the muscles accompanied the pain in 1937. Painful swelling of various joints of the body and particularly those of the hands, shoulders, and ankles was noted in 1941. This was accompanied by a weight gain of twenty pounds. She then complained of practically a con-

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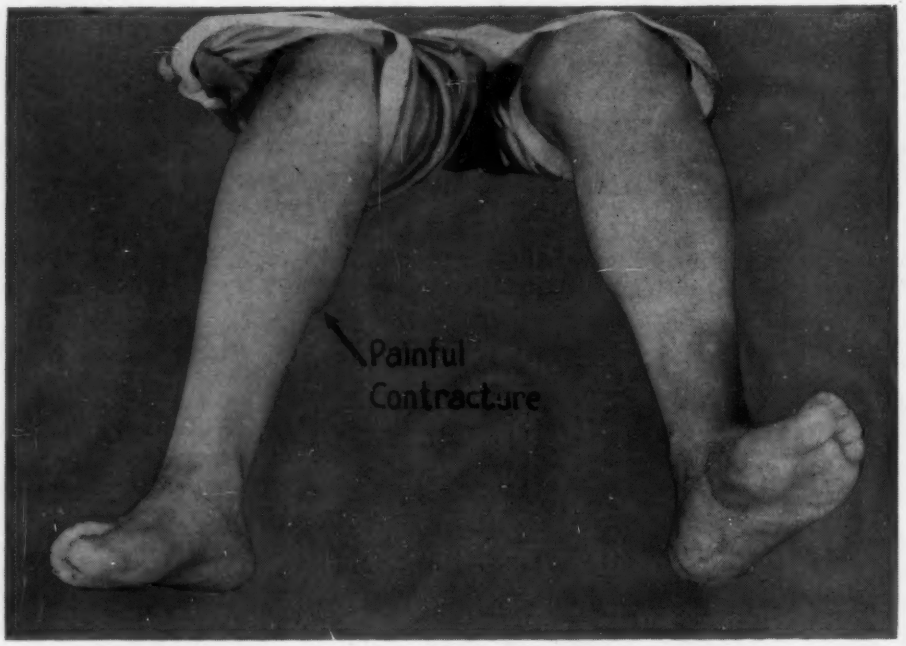
stant "spasm" of the right calf of four years' duration, whereas in the beginning the spasms were intermittent in character, each lasting about thirty minutes. A cramping sensation in the left arm and shoulder girdle, and in the muscles of the back then developed. The right arm and shoulder girdle were similarly involved and during 1941 retardation of movements of this side and severe headaches occurred. The patient had always been of a nervous temperament. There had been an exaggeration of this symptom following the surgical menopause in 1936. She stated she had a "nervous breakdown" in 1937 which required sanatorium care. Neurologic examination in 1942 revealed negative findings. The right calf was in a continuous state of contraction. Reflexes were all brisk and nonpathologic. Faradic and galvanic stimulation of the motor nerves was normal but there was a hyperirritability of the right calf muscles. A piece of the right gastrocnemius muscle was taken for biopsy. Sections of it showed normal striated muscle with areas of degeneration and hyalinization of muscle fibers. Some fibrosis of the intermuscular septa was present without a sign of active inflammatory reaction, parasites, or neoplasm. Pain was then the outstanding symptom. No hypertrophy of the muscles was found although the myotonic syndrome was present. The patient was unable to relax the affected muscles or to initiate a rapid movement. The myotonic reaction to mechanical and electrical stimuli was observed.

After leaving the Cleveland Clinic the patient continued to have almost constant severely painful spasms of the right calf muscles. Cramps often occurred at night but were worse on walking. Because of stiffness of these muscles, difficulty in arising from the sitting position and in beginning to walk was associated. The patient was exhausted after walking a short distance. There later occurred a constant increase in the size of the calf which was present even when there was no spasm. Frequently this area felt stone hard. Mental and emotional upsets did not seem to agitate the condition. Climbing stairs aggravated the pain. It finally became necessary for her to hire help to do the housework. She visited several physicians for treatment of this disease but without permanent improvement. Local application of heat gave only temporary and partial relief of pain. Liniments and pills produced similar temporary results. The sciatic nerve was injected at one time with novocain which, the patient believed, accentuated the pain. She became much depressed because of this continued disability and was discouraged by the many unsuccessful attempts to remedy the disease.

The patient entered University Hospital on Jan. 14, 1945, complaining of this condition but principally of episodes of epigastric distress which began approximately seven years prior to admission. These were characterized by gaseous eructations and abdominal distention. They occurred frequently after eating fatty foods. The patient had four to six attacks a year of vertigo, nausea, and vomiting of bile-stained fluid, each of which lasted for from twenty-four to forty-eight hours. The accompanying pain was sharp and intermittent in type. It frequently radiated to the tip of the right scapula and was aggravated by body movement. Often epigastric and upper right quadrant tenderness remained following the pain. Fever was associated during the attacks, but there were no chills. Jaundice of the scleras and the skin with marked pruritus was present intermittently for several years. During these attacks of jaundice the stools were clay-colored. Cholecystography revealed the presence of many gallstones in the gall bladder.

Physical examination showed the patient to be well developed and rather obese. Her stated age was 49 years. She did not appear acutely ill. The temperature was 98.4° F., with the pulse 70, respirations 20, and the blood pressure 126 systolic and 80 diastolic. The skin was warm, dry, and showed no evidence of jaundice. The pupils were regular, round, and reacted well to light and accommodation. The scleras were normal in color. The conjunctivae appeared normal. Nasal examination revealed no abnormalities. She wore a complete upper artificial denture. The lower teeth were in good repair. Examination of the oropharynx gave negative findings. There were no abnormalities of the neck, and no gross abnormalities of the chest. The breasts were obese and pendulous but otherwise normal. The lungs were clear to percussion and auscultation. The heart was normal in size to percussion; its sounds were of normal quality and no murmurs were present. There was marked tenderness on moderate pressure of the upper right quadrant of the abdomen. The point of maximum tenderness was at the Mayo-Robson area. The liver extended 1½ fingerbreadths below

the right costal margin on deep inspiration. It was tender and definitely enlarged on percussion. There was present a well-healed hysterectomy scar. Otherwise results of the remainder of the abdominal examination were negative. The right leg, even when relaxed, was definitely larger than its mate on inspection and measured 2.5 cm. greater in circumference



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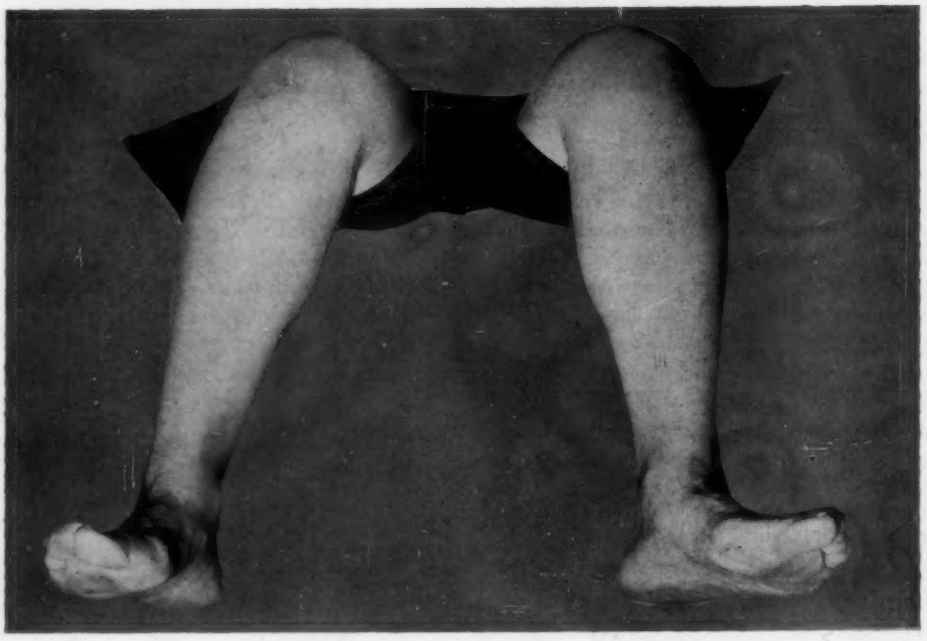

B.

Fig. 1.—*A*, The calf muscles of the right leg were outstanding, hard as wood, and very tender to palpation on Jan. 16, 1945, two days prior to cholecystectomy and choledochostomy. *B*, The right calf muscles returned to normal contour, size, and consistency and were nontender by April 12, 1947.

than the left at the mid-calf area. The calf muscles of the right leg when contracted were outstanding, hard as wood, and very tender to palpation (Fig. 1, *A*). There were no evidences of atrophy (Fig. 1, *A*). Gait was slow and labored and she walked the stairs with considerable difficulty. The reflexes were physiologic throughout.

On admission the red blood count was 4,800,000 with hemoglobin 13.2 Gm. per cent. The white blood cells were 13,500 with neutrophiles 69 per cent, lymphocytes 27 per cent, monocytes 2 per cent, eosinophiles 1 per cent, and basophiles 1 per cent. The segmenters were 64 per cent and the non-segmenters 5 per cent. The blood Kahn and Mazzini tests for syphilis gave negative results. The bleeding time using the Duke method was 1 minute 20 seconds and the clotting time using the Lee and White method was 4 minutes 40 seconds, which are normal. The icterus index was 5.0; the direct van den Bergh, negative; and the indirect less than 0.2 mg. per cent, which are normal. The blood urea nitrogen was 25.0 and the blood sugar 101.0 mg. per cent. The blood cholesterol was 190 mg. per cent, which is normal. The hippuric acid test for liver function yielded 2.90 Gm., which is also normal. The blood prothrombin was 60 per cent of normal, which is slightly decreased.

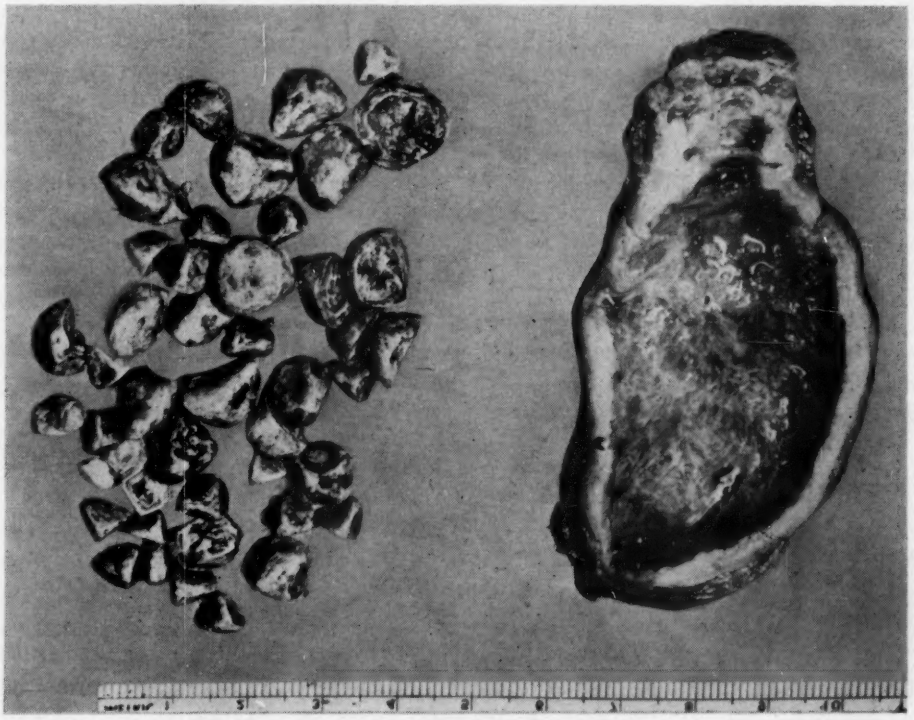

Fig. 2.—Chronic cholecystitis with cholelithiasis.

Preoperatively the patient received a high carbohydrate, high protein, low fat, and high vitamin diet. Glucose-reinforced fruit juices were given between meals and 1 ampule of synkayvite (vitamin K) was given on each of two days before operation. On Jan. 18 1945, exploratory celiotomy revealed the gall bladder to be greatly distended with many stones (Fig. 2). Its wall was edematous, thick, and showed evidence of chronic inflammation (Fig. 2). Dense pericholecystic adhesions were present which bound the gall bladder down to the common bile duct. The latter structure was easily uncovered and definitely dilated. The common bile duct was therefore explored just below the juncture of the cystic duct through an incision about 1 cm. in length. Stones could not be discovered and the duct seemed to be patent throughout. A small Kehr tube was therefore trimmed and placed in the common bile duct. The wound of the duct was then closed by interrupted sutures of black silk to prevent leakage of bile around the tube. The cystic duct as well as a cystic artery was then uncovered and

individually ligated with double sutures of medium black silk. The gall bladder was excised in the usual fashion and the uncovered area of the liver was reperitonealized with interrupted sutures of fine black silk. A medium-sized cigarette drain was placed in the pouch of Morison. Both the long end of the Kehr tube and the cigarette drain were brought through the abdominal incision. Five grams of microform sulfathiazole were then dusted lightly about the intra-abdominal operative area. The abdominal incision was closed in a routine manner using interrupted sutures of black silk in layers throughout.

The postoperative course remained uneventful. Adequate amounts of 10 per cent glucose in distilled water as well as normal saline solution were given during the first two days postoperatively. The cigarette drain was completely removed on the fourth day. Postoperatively the diet was increased rapidly as tolerated to the preoperative type of intake. Early ambulation was carried out. Synkayvite in adequate amounts was administered. The bile appeared dark green and cloudy so that two tablets of ketochol were given three times daily beginning on January 22. Twenty-four hours later definite increase in the amount of bile drainage was noted and this became more golden yellow in color by Jan. 25, 1945. The skin sutures were removed on the seventh day. Cholangiography was done on January 30, the twelfth postoperative day, using lipiodol, which visualized the left and right hepatic ducts, the common hepatic duct, and the common bile duct to be normal in appearance without evidence of stones or of obstruction. The lipiodol passed freely into the duodenum. The Kehr tube was therefore clamped. The patient remained symptom-free and this tube was removed on the fourteenth postoperative day. The patient was discharged on Feb. 3, 1945, to return to our office.

By Sept. 25, 1945, the spasms referable to the right lower extremity, which had been present for eight years prior to surgery, had practically subsided. She had been treated by various physicians throughout these years without relief. However, after cholecystectomy with choledochostomy the pain referable to the right calf muscles rapidly disappeared. Thereafter, the contracture of these muscles also disappeared gradually. At this examination she complained only of an occasional slight stiffness but no contractions of the muscles. Frequent follow-up examinations since September, 1945, showed the muscular hypertrophy to remain for a long time after the myotonic symptoms had disappeared. However, this limb gradually returned to a normal size so that on April 12, 1947, measurements of the lower extremities revealed them to be equal in circumference (Fig. 1, *B*) at 45.0 cm. above (7.5 cm.) the knees, 34.0 cm. below (7.5 cm.) the knees, 35.5 cm. at mid-calf (12.5 cm. below the knees), and 20.5 cm. at the ankles. Mental depression had disappeared since cholecystectomy so that she felt that life was now worth living. The headaches had completely disappeared. The symptoms referable to other parts of the body had disappeared to a great extent. Gait was normal and she was able to carry out all normal activities including housework.

SUMMARY

Apparently the etiologic factor which explained the myotonia and muscular hypertrophy in this case was a chronic calculous cholecystitis with an accompanying chronic hepatitis of several years' duration. After removal of the gall bladder and adequate treatment of the hepatitis the whole syndrome completely subsided. This case was also of unusual interest since it appeared to be the first of its kind reported to have occurred in a woman.

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HERPES ZOSTER AND THE SURGICAL ABDOMEN

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AMONG the many causes of abdominal pain which must be differentiated in the diagnosis of the surgical abdomen, herpes zoster may offer a difficult challenge to the examiner. That this syndrome may mimic intra-abdominal pathology has been pointed out by various investigators in the past, but the close simulation of conditions requiring surgical intervention is not clearly or readily appreciated. Two patients with abdominal pain as the primary symptom have recently been seen in whom the clinical picture of intra-abdominal disease was so closely simulated by herpes zoster as to cause difficulty in correct diagnosis.

In brief, the major clinical manifestations of herpes zoster are as follows: the disease is frequently preceded by an upper respiratory infection which antedates the onset of symptoms from the zoster infection by several days. The chief complaint is usually that of rather severe and steady, sometimes stabbing pain distributed in a radiating course along the extent of one or more peripheral nerves, usually in the trunk region. The skin eruption which is characterized by groups of vesicles on an erythematous base ordinarily comes on several days after the onset of the pain and is distributed also along the course of the sensory nerve. The disease usually attacks the dorsal root ganglia of the thoracic segments but commonly involves also the areas supplied by the trigeminal and first lumbar nerves. It is in the preherpetic stage of herpes zoster that confusion with visceral disease usually occurs.

The possibility of confusing herpes zoster with visceral disease has been previously noted by several authors. In 1902 Curtin[9] reported one case of "catarrhal appendicitis" which subsided and then was followed by herpes zoster. He also described mimicry of intrathoracic and renal pathology by the syndrome. In his *Differential Diagnosis* Cabot[4] listed herpes zoster as the cause of lumbar pain as often as all renal diseases combined. Litchfield[12] in 1913 wrote on acute posterior ganglionitis simulating surgical conditions in the abdomen. He cited cases where ureteral colic and cholecystic disease were ruled out by the appearance of herpetic rashes and quoted Marinacci's description of a case thought to be generalized peritonitis but later proved to be herpes. Barney,[1] Blanton,[2] and Young[14] have described cases of herpes zoster simulating renal disease. Boland[3] remarked on the lack of comment in dermatology books concerning the possibility of confusing herpes with acute abdominal disease. He then cited a case erroneously diagnosed as acute appendicitis, in which operation was fortunately delayed until the appearance of the herpetic eruption. Among other authors who have listed herpes zoster with diseases to be considered in the differential diagnosis of the acute abdomen are Paullin[13] and Comroe.[8]

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In an extensive review of 137 hospitalized cases of herpes zoster, Gais and Abrahamson[11] found that pain was the chief complaint in 118 patients. Of 34 cases in which abdominal or lumbar pain was the primary symptom, erroneous diagnoses were made in 26 cases. Failure to diagnose herpes zoster led to surgery in 2 instances. The erroneous diagnoses covered a wide range of abdominal diseases. Since this is the only large series of such cases yet presented in the literature, certain statistics supplied by Gais and Abrahamson are of interest. Most frequently the pain involved the right upper quadrant but all regions of the abdomen were included. Tenderness, rigidity, anorexia, nausea, and vomiting were present in many. The difficulty in diagnosis led to x-ray studies in 10 patients. Of the 6 patients with lumbar pain, all had costovertebral angle tenderness, 4 had dysuria, 3 frequency, 2 hematuria; and 1 nausea and vomiting. Retrograde pyelography was carried out in 5 of the 6 cases.

Intercostal neuralgia or posterior radiculoganglionitis is a syndrome described by Carnett[5, 6] and by Davis,[10] and this is said to account for many otherwise unexplained cases of abdominal pain. Carnett referred to intercostal neuralgia as the cause of pain in "pseudo-appendicitis," a designation for those cases of "appendicitis" which the pathologist is unable to confirm. Whereas skin hyperesthesia is usually explained on the basis of the viscerosensory reflex, Carnett attributed it to an intercostal neuralgia. In a report of over 250 school children suffering from pain in the area of distribution of the lower thoracic nerves, Davis concluded that the pains were due to a radiculoganglionitis (segmental neuralgia) caused by a neurotropic virus associated with the common cold. He suggested that vesiculation may be unusual in zoster and that subherpetic manifestations may be the rule. In only 2 of his 250 cases did herpes develop. The characteristic features of this syndrome are segmental pain and skin hyperesthesia. Davis pointed out the similarity of this condition to appendicitis, renal colic, cholelithiasis, pleurisy, colitis, etc. Fever is usually not present but vomiting may be associated. However, in constrast to the unilateral nature of herpes zoster, 40 per cent of the cases reported by Davis showed bilateral symptoms. In the cases referred to by Carnett the symptoms were frequently bilateral.

We have recently seen a patient admitted to the hospital with a presumptive diagnosis of perinephric abscess in which the diagnosis of segmental neuralgia seemed justified. A brief report follows.

CASE REPORT

A 15-year-old colored boy was admitted to St. Philip Hospital complaining of left lower quadrant and left flank pain of two weeks' duration. Three weeks prior to admission, the patient had been discharged following treatment for diabetic acidosis and mild bronchopneumonia. The pain was described as originating in the back and radiating anteriorly into the left lower quadrant. Anorexia was present but no nausea, vomiting, bowel disturbances, or urinary symptoms. The pains had increased in severity during the three days before admission. On admission the temperature was 99.6° F., pulse 70, respirations 22. With the exception of a mild conjunctivitis, the positive findings were limited to the trunk and abdomen. Examination revealed a soft abdomen without spasm. There was apparent tenderness in the left lower quadrant, flank, and costovertebral angle. The tenderness did not

appear to be increased by deep palpation. It was still present on examination with the abdominal muscles tensed, thus indicating that most of the pain at least was parietal (positive Carnett's sign). There was a definite band of hyperesthesia extending from the midline of the back in the approximate distribution of the eleventh thoracic nerve and stopping sharply at the midline anteriorly. The white count and urine were normal. A spinal fluid examination showed only 3 lymphocytes and a protein of 50.

Following an intercostal nerve block with 1 per cent novocain in the region of the tenth and eleventh thoracic nerves posteriorly, the pain and hyperesthesia completely disappeared and palpation no longer elicited tenderness. This relief was permanent with the exception of some persisting hyperesthesia in the distribution of the posterior ramus of the tenth thoracic nerve. During a period of observation lasting over ten days, herpetic lesions did not develop.

The following two cases simulating surgical disease presented definite evidence of herpes zoster.

CASE 1.—A colored man, aged 30 years, was admited to St. Philip Hospital on Oct. 11, 1946, complaining of abdominal pain and vomiting of one day's duration. Approximately twenty-four hours before admission he had become nauseated and vomited. Shortly thereafter he noted the onset of crampy pain in the right lower quadrant which soon involved the entire abdomen and later localized again in the right lower quadrant. He continued to vomit intermittently until admission. No history of urinary symptoms or other gastrointestinal disturbances could be elicited. For four days prior to admission he had noted some tenderness in the right flank and right lower abdomen.

Temperature on admission was 100.4° F., but this shortly afterward was recorded as 99° F., per rectum. Pulse was 77, respirations 28. Abdominal examination revealed tenderness with rebound in the right lower quadrant near McBurney's point, with associated skin hyperesthesia. One observer thought that muscle spasm was present in the right lower quadrant. There was some tenderness high on the right by rectal examination. Inspection of the skin revealed small groups of vesicles on an elevated base extending in a linear fashion from the midline of the back into the right lower quadrant in the approximate distribution of the eleventh intercostal nerve. There was a small group in the region of McBurney's point, approximately 3 cm. in diameter.

Laboratory examination revealed a red blood cell count of 2,900,000, with 60 per cent hemoglobin, white count of 6,900, 72 per cent polymorphonuclears, and 28 per cent lymphocytes. Urinalysis was negative except for 1 plus albumin. Despite the obvious presence of herpetic lesions it was felt that the symptoms and signs were sufficiently suggestive of acute appendicitis to warrant an exploratory laparotomy.

The abdomen was opened through a McBurney incision. The appendix appeared grossly normal; there were a few small mesenteric nodes which did not appear to be inflamed. Pathologic report on the appendix was chronic healed appendicitis with fibrous obliteration of the lumen. There was some round-cell infiltration but no evidence of acute inflammation. The patient's abdominal pain was not relieved by operation and at the time of discharge five days later the rash was still present.

CASE 2.—A white man, aged 70 years, was admitted to the Medical College Hospital on Nov. 5, 1946, complaining of abdominal pain of six days' duration. Six days before admission the patient had noted the sudden onset of severe pain in the right lower quadrant, radiating at times into the right flank. The pain became dull and aching, was severe enough to interfere with sleeping, and persisted until admission. There were no crampy or colicky pains. Anorexia had been present, but no nausea or vomiting. A vague history of recent nocturia and dysuria was obtained. The past history was not directly contributory. Six weeks before admission the patient had suffered a short period of constipation. For forty years he had passed bright red blood per rectum intermittently. There was no history of weight loss and the appetite had been good until the presenting illness.

On admission the temperature, pulse, and respirations were normal. Physical examination revealed a soft, scaphoid abdomen with diffuse tenderness in the right lower quadrant

extending into the flank and with some costovertebral angle tenderness. No hyperesthesia of the skin was noted. Rebound tenderness was not present. No organs or masses were palpable. Peristalsis was somewhat hyperactive and continuous. Rectal examination was negative with the exception of tender external hemorrhoids and an enlarged prostate.

Laboratory examination revealed a white blood cell count of 6,800, with 63 per cent polymorphonuclears, 30 per cent lymphocytes, 2 per cent eosinophiles, and 5 per cent monocytes. The hemoglobin was 96 per cent, with a red blood cell count of 4,650,000. Initial urine examination showed a specific gravity of 1.012 and was otherwise normal. A definite diagnosis could not be made on admission, but a carcinoma of the right side of the colon or some kidney lesion was considered most likely. Blood chemistry revealed a sugar of 93, nonprotein nitrogenof 30, total proteins 6.6, with albumin 4.0. Flocculation was negative. Total phenolsulfonphthalein excretion was 43 per cent and Mosenthal concentration 1.020. Stools were negative for blood. A proctoscopic examination showed only internal and external hemorrhoids. Intravenous pyelogram and barium enema were likewise normal.

On the fourth day after admission, ten days after the onset of pain, herpetic lesions consisting of vesicles arranged in small groups surrounded by areas of erythema appeared on the trunk. The groups were separated by areas of normal skin. The lesions extended from the right side of the spine almost around to the umbilicus in the distribution of the tenth intercostal nerve. By the time of the appearance of these lesions the patient's abdominal soreness and tenderness had practically subsided. At the time of discharge on the eighth hospital day the lesions were beginning to fade.

DISCUSSION

In the first case of herpes zoster presented, in which the additional diagnosis of appendicitis was made, a posterior intercostal nerve block would have permitted more accurate evaluation of the apparent deep tenderness. The application of Carnett's test, that is, palpation with the abdominal musculature tense, would probably have suggested that the pain and tenderness were predominantly parietal. Under such conditions, one would expect that the tenderness would remain unchanged or be only slightly diminished, in contrast to disappearance of tenderness in intra-abdominal disease. The absence of severe systemic symptoms and the normal white count were consistent with the diagnosis of herpes. Rarely does the temperature rise above 100° F. in herpes. In the large series of cases presented by Gais and Abrahamson the leucocyte count ranged between 5000 and 7000, and in none was it reported above 10,000.

In the second case, the long interval of ten days between the onset of symptoms and the appearance of the rash postponed the correct diagnosis and permitted an unnecessary number of expensive laboratory procedures to be carried out. This interval, though longer than the average reported, is certainly not unusual. An examination of the spinal fluid may or may not be of value. Though a lymphocytosis of the spinal fluid is usually stated to be present in herpes zoster, Gais and Abrahamson found it in only 50 per cent of the eleven patients so examined. Davis stated that in the cases of so-called intercostal neuralgia mentioned previously, the spinal fluid was almost always negative.

A recognition of the radicular nature of the pain, of the presence of hyperesthesia, the degree of which may vary considerably, and a careful examination to demonstrate the segmental distribution with limitation at the midline anteriorly will aid materially in the differential diagnosis of herpes zoster and the surgical abdomen. Gais and Abrahamson point out that careful examination of the back sometimes will reveal a single vesicle indicating the correct diagnosis.

SUMMARY

1. Herpes zoster may offer a difficult challenge to the examiner in differentiating causes for abdominal pain.

2. The characteristic pain in herpes zoster is one radiating from the back to the midline anteriorly in the distribution of one or more spinal nerves, usually in the lower thoracic segments.

3. The syndrome usually follows an upper respiratory infection by several days and may be manifested as an intercostal neuralgia without the herpetic eruption.

4. Carnett's test, to suggest whether the pain and tenderness arise in the abdominal wall or in the viscera, is a useful adjuvant in the examination of a patient with abdominal pain.

5. Careful plotting out of the area of skin hyperesthesia and novocain block of the nerves supplying this area may aid in establishing the origin of the patient's presenting complaint.

6. Two cases of herpes zoster and one case resembling intercostal neuralgia are reported to show the close simulation of the acute surgical abdomen by these conditions.

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MESENTERIC THROMBOSIS

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THE purpose of this paper is to review briefly the subject of mesenteric thrombosis from the standpoint of current literature and to present a series of forty cases encountered at the Mercy Hospital during the last twenty years. Of more importance, it will stress two ideas which are deserving more emphasis than they have previously received. One is that mesenteric thrombosis occurs more commonly in a milder form than is often appreciated, accounting for many vague abdominal symptoms in older people without there necessarily being a massive abdominal accident. The picture may be compared to "angina" caused by coronary insufficiency, "cerebral spasm" which results from cerebral circulation insufficiency, or "intermittent claudication" due to insufficiency of the circulation of the extremities. A similar syndrome may occur in the abdomen where intestinal circulation is impaired in a gradual manner as by arteriosclerosis. We believe that it is possible to predict or anticipate a massive abdominal occlusion in some of these people, just as severe coronary occlusion may be predicted in people with angina, and gangrene of extremities in people with intermittent claudication. As is pointed out by Dunphy,[1] this condition has been described for years, but a lack of post-mortem evidence has prevented its acceptance as a clinical fact. As early as 1905, Pal[2] of Austria stressed this idea when writing about vascular crises.

Second, it will be emphasized that in spite of what one's thoughts may be in regard to surgery in general, there is no place for conservatism in the treatment of this condition when it presents itself as an acute abdominal emergency. Radical surgery is the only hope in saving life.

INCIDENCE

Ficarra,[3] in November, 1944, brought the medical literature up to date. He reported at that time 569 cases with 35 successful resections. Since then, no large series has been presented. A review of the literature since his article adds 7 more cases with 3 successful resections. To these we now add 40 cases with 5 successful resections; thus bringing the totals to 616 cases with 43, or 7 per cent, successful resections. Since there was an average of 10,000 admissions per year in the Mercy Hospital over this period of time, we find that the incidence in this institution was one case in 5,000, or .002 per cent.

Of our 40 patients, 23 were men, 17 women. All 40 occurred in white people; no Negro receiving the diagnosis in spite of the fact that many are admitted to this institution. In comparing the incidence with other places, we find that the Michael Reese Hospital in Chicago had 44 cases in ten years, or .105

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per cent of all *surgical* admissions. The Kings County Hospital in New York had 35 cases in eight years. Warren and Eberhard[4] found that only .041 per cent of the admissions in their institution received this diagnosis.

Although the incidence of mesenteric thrombosis is greatest between the third and sixth decades, it may occur at any age. In our series the youngest patient was 27 years old, the oldest 82. Of our cases, 57 per cent occurred between the ages of 40 and 60 years. Laufman and Scheinberg[5] reported cases where infants 10 days, 11 days, and 5 years of age were operated on for this condition. These are the exceptions and for the most part the condition occurs at the age where degenerative diseases begin to appear.

In this series of 40 cases, the diagnosis was definitely proved in 27, or 67 per cent, by either operation or autopsy. Of these 27 cases, 11 came to autopsy, 16 were operated upon, and 3 came to autopsy after operation. The remaining 13, or one-third of the total, were diagnosed clinically and, of course, it is quite impossible to prove the diagnosis in this group.

MORTALITY

The group which was not proved by operation or autopsy, that is, the 13 cases, may be dismissed by saying that of this number 12 patients died, for a mortality of 92 per cent. Of these 13 cases, 8 were the results of a primary heart disease, 3 followed previous surgery, and 2 were primary in nature. Operation was not attempted in any of these cases because of the generally universal feeling by the surgeon that the patient could not tolerate surgery. Perhaps it is wishful thinking that at least one of these patients might have benefited by surgery.

In the proved group of 27 cases, 19 patients were operated upon and 5 lived, for a mortality rate of 73 per cent. Of this group of 19, there were 6 patients in whom nothing but the diagnosis was established by opening and closing the abdomen. One cannot consider these individuals as having been operated upon in the ordinary conception of surgery. All 6 died. Of the remaining 13, where some operative procedure was done, 5, or 39 per cent lived. So, of all cases where some operative procedure, other than just opening and closing the abdomen was performed, the mortality rate was 61 per cent. In the group in which nothing was done, the mortality rate was 95 per cent. Thus, it would seem that surgery gives the patient about one chance in three to survive, while watchful waiting has little to offer but death.

Our operative mortality figures compare favorably with those of other clinics. Michael Reese has a rate of 67 per cent; Kings County, 71 per cent; a review of 104 cases from the literature by Brown[6] in the American Journal of Surgery, 68.2 per cent; and Whittaker and Pemberton[7] reported from Mayo Clinic a mortality of 84 per cent following surgical intervention.

ANATOMY AND PATHOLOGIC PHYSIOLOGY

The blood supply to the small bowel is derived from the superior mesenteric artery which also supplies the large bowel as far as the middle of the transverse colon. Large bowel distal to this is nourished by the inferior mesenteric artery.

The superior mesenteric artery gives off from ten to sixteen intestinal branches which are divisible into two groups, jejunal and ileal, passing between the layers of the mesentery toward the small intestine. Each of these divides into two branches which anastomose with those of adjacent arteries to form a series of arcades from which secondary branches are given off. With the lower ileal arteries this may happen four or five times so that there may be four or five tiers or arcades. In the jejunum there may be only two arcades present. From the terminal arcades, straight vessels pass to supply the intestinal wall. These so-called "vasa recta" do not anastomose. Of prime importance in knowledge of circulation of the abdomen is the fact that the inferior pancreaticoduodenalis, another branch of the superior mesenteric artery, anastomoses with the superior pancreaticoduodenalis which comes from the coeliac axis. This forms an obvious channel for the development of collateral circulation in cases of occlusion of the superior mesenteric artery. The greatest benefit derived from this collateral circulation is in cases of gradual occlusion rather than in those of a sudden nature. This collateral circulation no doubt plays an important role in those occasional patients with mesenteric thrombosis who get well even though no surgery is done.

The superior mesenteric artery arises from the aorta at such an angle immediately below the celiac axis that its main stem parallels to some extent the abdominal aorta. Thus, it has almost a direct connection with the heart and for this reason is particularly vulnerable to emboli from it. As a matter of fact, of any 100 cases of arterial occlusion of the abdomen, 96 per cent occur in the superior mesenteric artery, while the remaining 4 per cent are distributed in the inferior mesenteric artery and the celiac axis.

In contrast to the arterial distribution, all blood collected into the veins of the abdominal part of the digestive tract passes into the portal vein by which it is filtered into the liver and then through the hepatic veins to the vena cava. A thrombus arising in the lumen of a vein may do one of two things: (1) give off an embolus into the cephalic channels, or (2) block off venous channel so that a descending thrombosis extending toward the bowel might occur.

The pathologic picture which results from vascular occlusion is infarction and hemorrhage throughout all layers of the bowel with accumulation of blood in the lumen. It seems strange that this should occur in an organ where the collateral circulation is so abundant. The reason was proposed by Litten in 1889 when he showed that the superior mesenteric artery acts as an end artery. Sudden occlusion of a branch may set up a severe spasm of the musculature of the intestines, sometimes as far as from the ligament of Treitz to the middle of the transverse colon. This spasm is due to the sudden anemia which results from the cessation of arterial blood flow. At this stage the bowel appears as a firm, white, rippled structure; then, in a matter of three or four hours, as the musculature fatigues, it relaxes, some parts more rapidly than others. The result is a splotching of the bowel with bluish-red areas of discoloration. In forty-eight hours the musculature is completely relaxed and the entire bowel has a dark blue, blood-soaked appearance. These facts lead to the emphasis of the idea that wide radical resection is absolutely necessary. Although the surgeon may

feel that he is wide of the gangrenous bowel in the resection, if he is not sufficiently far away, he may be making the anastomosis in a part of bowel which has not yet relaxed, but within a few hours will become engorged and gangrenous. The exact mechanism of hemorrhagic infarction has always been controversial. Experimental work has shown that, as the musculature of the intestine relaxes, the negative pressure created in both arterial occlusion and venous occlusion is sufficient to draw blood into the walls of the bowel, causing it to become markedly engorged, thus having the characteristics of other infarcted tissue. Whenever venous obstruction occurs it is quite easy to see why the damming back and congestion of blood should occur. Pathologically, then, the picture of mesenteric thrombosis shows microscopically an involved segment of bowel which is thickened, edematous, dark red in color, and rapidly becoming gangrenous. The lumen contains blood and the peritoneal cavity contains bloody fluid. Microscopically the lumen of the bowel is filled with a large amount of hemorrhagic edema fluid. The mucosal lining shows all stages of degeneration ranging from edema to necrosis. Edema is seen in the submucosa. The muscular layer and serosa show a hemorrhagic reaction. Frequently the vessels are seen to be dilated and filled with erythrocytes. The mesentery itself is usually markedly thickened, containing large patches of hemorrhage, and the mesenteric glands may be swollen and hemorrhagic.

ETIOLOGY

Many authors have written at length on the etiologic factors of mesenteric vascular occlusion. It may suffice to present a simple outline of the numerous predisposing conditions.

Arterial embolus of the mesentery is seen most frequently in patients with heart disease and the embolus usually arises in the left side of the heart, either from vegetations on the valves or a thrombus in the auricle.

Venous emboli are practically nonexistent.

Arterial thrombosis of the mesenteric artery may be most frequently traced to atheromatous degeneration of the vessel wall, or arteriosclerosis.

Venous thrombosis on the other hand is most frequently associated with infections in organs or viscera that are tributaries to the portal vein. Thus, appendicitis, pelvic disease, or ulcerating carcinoma of the colon may lead to venous thrombosis. Also, surgery of the stomach, appendix, strangulated hernia, and pelvis are predisposing factors.

Primary venous thrombosis, unlike arterial thrombosis, is quite rare. When it occurs it is due to endophlebitis or phlebosclerosis.

Other conditions which have led to thrombosis of the mesenteric artery or vein have been (1) blood dyscrasias, such as polycythemia vera and splenic anemia; (2) trauma to the mesenteric vessels; (3) mechanical causes, as portal stasis, pressure from tumors, adhesions and bands; (4) following ablation of the lumbar sympathetic chain (mentioned in the literature recently[5] (the mode of action here is unknown); and (5) a small group of cases in which no primary cause of thrombosis can be demonstrated.

Of our series of cases we have found the etiologic factors to be as follows:

(1) 8 of 11 autopsies showed primary intimal arteriosclerosis with thrombosis of the superior mesenteric arteries
11 other cases were probably primary arteriosclerosis with thrombosis; we say, "probably," because no other factors as heart disease, trauma, infection, etc., were present

(2)	Heart disease	14 cases (2 proved by autopsy)
	Arteriosclerotic H.D.	4 cases
	Rheumatic H.D.	3 cases
	Coronary H.D.	3 cases
	Unclassified H.D.	4 cases
(3)	Following surgery (probably venous thrombosis)	5 cases (none autopsied)
	Strangulated hernia	2 cases
	Gynecologic operation	1 case
	Appendectomy	1 case
	Gastroenterostomy	1 case
(4)	Following delivery	1 case
(5)	Primary portal vein thrombosis	1 case (autopsied)
(6)	Undetermined etiology	2 cases

Thus, in this series, 7 were venous thrombosis and 19 were arterial thrombosis; 14 were arterial emboli and 2 were undetermined. This does not conform with findings in the literature. Moore[8] blamed venous obstruction for 75 per cent of the cases. Shively and Renshaw,[9] from the Cleveland Clinic, reported that 70 per cent of all cases are venous in origin; Boyd,[17] that the venous type is more common. Whittaker and Pemberton in 60 cases found 19 to be arterial and 27 to be venous. However, both Larson[10] and Trotter[11] concurred with our findings that arterial thrombosis occurs more frequently than venous thrombosis.

CLINICAL PICTURE

Two cases on our service in the last year summarized the clinical picture. These are cases which will help prove (1) that radical surgery is necessary to save life, and (2) that oftentimes this condition may cause unexplained abdominal symptoms due to the mildness and gradual onset of the pathologic process. Both of these patients recovered.

CASE 1.—F. S., a white man, 69 years of age, was admitted to the emergency room on May 26, 1945. Five days previously he had suddenly complained of pain in the stomach with mild indigestion. The next night he had a sudden severe pain in the lower abdomen which radiated from the midline to both sides. The following day, three days after onset, the pain continued and he vomited. It was necessary to give morphine to obtain relief. Since the onset of the symptoms he had had no normal bowel movement. Stools were loose and on three occasions contained blood. Pain grew worse until the time of admission on May 26, 1945. Physical examination on admission showed a man slightly cyanotic, obviously in pain, with a distended abdomen and generalized abdominal tenderness. There was an occasional peristaltic tinkle and a fair amount of diffuse rigidity. Temperature was 102° F., pulse 96, respirations 20, white blood cells, 15,700. He was immediately taken to the operating room

and when the abdomen was opened, pink, blood-stained fluid occupied the peritoneal cavity. About 14 cm. of blue-black gangrenous bowel were present. The bowel was resected very wide of the gangrene on either side so that it was felt that we were well beyond the involved area of bowel. A wedge-shaped piece was removed from the mesentery and an end-to-end anastomosis was performed. Aside from some mild atelectasis and breakdown of the wound, he left the hospital July 29, 1945, sixty-two days after admission, apparently well. During his stay in the hospital, a cardiovascular survey showed no cardiac disease. This man was well and doing his normal work when last seen in April, 1948.

CASE 2.—W. H., a white man, aged 49 years, was admitted to the emergency room on our service April 5, 1946. His history revealed that four days before admission he was seized with severe abdominal pain, sharp and generalized, over the entire abdomen. He took several enemas, with no effect. At no time was there any blood in the stool. Nausea and vomiting began the day of admission. Examination on admission revealed a rather heavy-set pale, clammy individual with a greatly distended abdomen. There was diffuse tenderness and peristalsis was absent. A roentgenogram of the abdomen failed to reveal air or obstruction. Electrocardiogram was normal. He was given plasma and taken to the operating room immediately. Upon opening the abdomen, pink, hemorrhagic fluid filled the peritoneal cavity. About two-thirds of the small bowel was gangrenous. This bowel was resected well beyond the gangrenous areas on both sides and it measured 56 inches in length. A wedge of the mesentery was likewise removed. The laboratory found extensive mesenteric artery thrombosis. An enteroanastomosis was performed. The patient made a rather uneventful postoperative recovery and was discharged May 4, 1946, twenty-nine days after operation, apparently well. A most interesting fact was concerning his past medical history. Approximately three and one-half years before, in October, 1942, he had been operated upon by one of us for a very similar complaint. At that time nothing was found in the abdomen to account for the symptoms. Between the two operations, for a period of two years, he had some vague abdominal distress. The following is a follow-up note written in the records Jan. 15, 1943, which is very impressive: "Patient was in the office today for a follow-up examination. He now has the same type of complaints that he had preoperatively, namely, distention, swelling, and some cramplike pains in the upper abdomen; also tenderness in the same area in which he was tender preoperatively. I am still at a loss to explain this patient's symptoms."

In review of the literature, one is amazed at the lack of unanimity as to the symptoms and physical findings in this condition. Some authors state that continuous pain is a feature, others that pain is intermittent; some show much concern about vomiting, others about the lack of it. We feel that very frequently the diagnosis of mesenteric thrombosis is one which is made by exclusion. In our cases, no definite picture is universally present. Bloody stools about which so much is written occurred in only two cases. Furthermore, it is felt that to differentiate mesenteric artery thrombosis from mesenteric venous thrombosis is clinically practically an impossibility. In the differentiatial diagnosis, one should bear in mind such conditions as (1) acute hemorrhagic pancreatitis, (2) acute cholecystitis, (3) ruptured peptic ulcer, (4) ruptured abdominal viscus, (5) diverticulitis, and (6) atypical heart disease. While the actual diagnosis may be difficult, the condition almost always presents itself as an "acute surgical belly."

COMMENTS

Both cases confirm the fact that when actual gangrene of bowel is present, radical surgery is the only treatment. Resection and anastomosis are advocated as the most desirable surgical procedures. Resection must be sufficiently wide to remove edematous bowel adjacent to the gangrenous area. It is generally

agreed by all that exteriorization of the bowel, enterostomy, and cecostomy are futile. Every patient in our series, six in number, in whom these procedures were done, died. Such men as Brown,[6] Beigler,[12] Thomas Moore[8] of London, and Renshaw[9] of Cleveland Clinic, in their writings on the subject, all confirmed this idea.

Of the five patients who lived following surgery in our series, only the two cases reported in detail in this paper were cases of extensive gangrene of bowel. Of the other three, two had only small areas of gangrene and one had a small area of terminal ileum involved. Thus, actually only two patients with extensive gangrene of the bowel have recovered by surgery and in both of these cases, both on our service within the last year, very wide resection with anastomosis was performed. Thus, it would seem, although the number of cases admittedly is relatively few, that for extensive gangrene no other procedure is acceptable.

The second case emphasizes the fact that mesenteric thrombosis may occur in a mild form and cause vague abdominal symptoms. Several others in our series and many more reported in the literature[13] confirm the idea that if the history of people who have primary mesenteric thrombosis due to atheromatous change in the vessels of the mesentery is gone into, one will find that over a period of months or years these individuals have had some abdominal distress, perhaps after a heavy meal, after severe exertion, or other times when blood supply to the gut may be impaired. Therefore, when the surgeon opens the abdomen of an elderly individual and finds nothing, he may presume that this condition is a possibility.

TREATMENT

The treatment of this condition is primarily surgical, the aspects of which have already been mentioned. Regarding the use of dicumarol and heparin, one thing is certain—they will never act as a cure. Dicumarol will be tried in our next case. However, our appraisal of it will be conservative. It would have been very easy to have given these drugs credit, if they had been used, for the success in the two reported cases. The value of these drugs in reducing operative mortality by preventing propagation of the parts of the thrombus which may remain following surgery is questionable. Moses,[14] of the University of Pittsburgh, showed experimentally that heparin and dicumarol in adequate dosage did not prevent the development of experimental intravascular thrombosis in the presence of stasis of the venous circulation. On the other hand,[15] they are reported to be of great usefulness particularly in arterial occlusion. Here they prevent extension of the thrombosis. However, it must be emphasized that in venous thrombosis especially, it may be extremely dangerous to use these drugs preoperatively. Death may be hastened because of continued bleeding into a bowel which is already hemorrhagic.

Other treatment of this condition is purely supportive and symptomatic. Plasma and saline solution for combating shock and fluid loss, opiates for the relief of pain, oxygen and circulatory stimulants, Levine tube for the relief of distention—all are to be used when indicated.

SUMMARY AND CONCLUSIONS

1. Radical surgery, that is, wide resection and anastomosis, is the only tenable treatment in those cases where there is extensive gangrene of bowel.

2. The condition may often present itself in a mild form, not always as the massive accident as is so commonly thought.

3. Mortality rate of the patients in the Mercy Hospital was, for those operated upon, 61 per cent, and for those not, 96 per cent. The total mortality rate was 85 per cent for 40 cases.

4. Of 40 cases, 57 per cent of the patients were between the ages of 40 and 60 years, with the youngest 27 and the oldest 82.

5. A brief discussion of the anatomy and pathologic physiology was presented with emphasis on collateral circulation.

6. An outline of etiologic factors was presented and arterial thrombosis of arteriosclerotic origin was the most common cause in our series. This is not the case in the literature.

7. Presentation of two cases on our service demonstrated the clinical picture of this condition. The signs and symptoms are not consistent.

8. We believe that the use of heparin and dicumarol must be considered. They may possibly be of great value postoperatively.

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OBSERVATIONS ON AN ABSORBABLE POWDER TO REPLACE TALC

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THE use of talc as a lubricant on gloves in surgery has been questioned for the past ten years. Several authors have called attention to the dangers of talc as a factor in the production of adhesions and of talc granulomas. Difficulty has been encountered in finding an acceptable substitute for talc. We present a review of the present literature on this subject and offer a specially processed starch as a substitute for talc.

The study of talc and its effect on the human body begins with Thorel[1] in 1896. He found talc or soapstone remaining in the incinerated lung of a woman supposedly dying from tuberculosis, who had worked for some years in the handling of products made from soapstone. In 1913, Harrison[2] suggested cultures of living tissue as a means for the study of the response of cells to directive stimuli. Lambert,[3] the year previous to this, had employed the same method and reported the formation of foreign body giant cells in vitro by the addition of foreign objects such as Lycopodium spores and cotton spores to cultures of chick embryo spleen. Sayers,[4] in 1924, began studies at the Pittsburgh Station of the United States Bureau of Mines to determine the action of various dusts when injected into the peritoneal cavity of guinea pigs. The conclusion he reached was that live animal tissue in all parts of the body tended to react in essentially the same manner to foreign bodies. This work was further reported by Miller and Sayers[5, 6] in 1934 and 1935. In the 1935 article Miller described the effect of soapstone and the formation of giant cells.

Lanza[7] in 1938 described the physiologic effects of different forms of talc. Talc produced a less active response than some of the other materials tested, but of a similar character.

Gardner,[8] in 1938, also described the irritative effect of talc, in his article on pneumoconiosis. When talc was injected directly into the testes of guinea pigs, it was found that a very active cellular proliferation was produced within six months.

Since 1919 there have appeared various articles describing a condition, found particularly in the peritoneum, resembling tuberculosis, but which was recognized as not being a true tuberculous lesion. Hertzler[9] in 1919 described it as a pseudotuberculosis. In 1933, Haythorn[10] described nodular lesions of the peritoneum, among these a pseudotuberculosis and foreign body granulomas. In 1933 also, Antopol[11] in reporting on granulomas caused by lycopodium, reported the case of a man 34 years of age who had had a laparotomy. Granulomas were found and within the giant cells refractile bodies were discovered, morphologically identified as crystals of talc. In his conclusions he stated

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definitely that granulomatous lesions may be caused by talc. Erb,[12] in 1935, described Lycopodium granuloma and urged against the use of Lycopodium as a dusting powder in operating rooms.

Owen,[13] in 1936, described a patient in whom granulomas were found due to talc. This prompted her to study the effect of talc intraperitoneally in 120 rabbits. Autopsies were done on these animals at 35, 45, 60, 90, 120, 180, 210, and 300 days after the dusting operation. Eighty-eight of these animals were autopsied. In each instance a varying number of small, slightly elevated, grayish-pink nodules were found on the peritoneal surface of the intestine. She suggested that talc be removed from the surface of the gloves before operating.

In 1937, Fienberg[14] reported on two cases of granuloma caused by talc, and was able to produce a similar lesion in the peritoneum of the mouse. He stated that indiscriminate use of talc in the operating room may produce granulomatous lesions. He suggested also the use of polarized light in recognition of the crystals in these lesions. In 1940, Ramsey and Douglass[15] called attention to the production of granulomas by talc and reported three such cases. They warned against the indiscriminate use of this powder in abdominal or other surgery, and in the use of rectal or vaginal suppositories containing talc.

Byron and Welch,[16] in 1941, discussed complications from the use of glove powder and suggested that, in addition to the formation of granulomas, sinus tracts might be formed. They stressed the necessity of washing off as much of the powder as possible before surgery. Ramsey[17] in 1942, described four more cases of talc granulomas, and stated that the use of polarized light was of great help in making the diagnosis. He further stated that more attention should be given to possible sources of irritation in the operating room itself, from surgical dressings, rubber gloves, and drains. He urged that no excess be left in the finger tips of the gloves. A tear while working in the peritoneum or any other body cavity could heavily contaminate the area. Weed and Groves,[18] in 1942, published a most interesting article regarding surgical gloves and wound infections. They called attention to the fact that in 4,549 operations, 35,763 gloves were used, and that of this number 8,103, or 22.6 per cent, showed perforations which had occurred during the surgery. Not only would this allow infections to travel from the hand to the surgical field, but would allow powder as well to escape.

German,[19] in 1943, described dusting powder granulomas following surgery and stated that talc, while chemically inert, promptly induces a marked tissue reaction in the form of granulomas. The formation of the granulomas is a protective mechanism which might interfere with the normal healing process depending on the site and the abundance of the granulomas which are present. German felt that adhesions do not develop without some form of traumatization of the peritoneum sufficient to produce exudation of fibrin. It was his opinion that in the presence of peritoneal trauma with exudation of fibrin, talc plays a secondary role in that it is caught up in the fibrin and is incorporated in the adhesions. Seelig, Verda, and Kidd,[20, 21] in 1943, called attention to the disadvantages of talc in surgery, and suggested potassium bitartrate as a substitute.

Seelig,[22] and Seelig and Verda,[23] in 1944, stated that talc can produce pathologic changes that may deceptively resemble cancer or tuberculosis. He urged the abandonment of the use of talc in surgery and suggested the use of potassium bitartrate. Seelig,[24] again in 1945, called attention to the danger of the use of talc on gloves in surgical ampitheatres, and urged strongly a substitute powder for talc; he proposed the use of a formaldehyde-treated starch, and stated that after using it for four months he found it completely safe. In 1945, Seelig and Verda[25] redescribed the dangers of talc, and showed photographs of the effect, intraperitoneally, of talc in rats.

Talc may exert deleterious influences in industrial applications as well as surgery. Its use is ubiquitous according to Lichtman and associates.[33] It may be employed for many purposes such as a cleaning agent for barley, beans, and coffee, as a packing and conserving agent for fruits and vegetables, as a filler in toothpaste, and is found in some chewing gums, candies, and suppositories—to mention but a few of the many fields where it is employed. It is a question whether in these industrial uses as well, its dangers, though perhaps less recognized, may be as real as in surgery.

In a study of plants engaged in the crushing and milling of talc, Dreessen,[26] in 1933, reported that silicate dust of tremolite talc and slate induces a fine, diffuse, bilateral fibrosis of the lungs which is definitely demonstrated in the x-ray view. In 1935 the same author[27] investigated two talc mills in Northern Georgia in an effort to determine whether there was a connection between the talc dust exposure and the high tuberculosis mortality rate reported in the county in which the industry was located. Physical examinations and radiographs were made on sixty-six men and women who were exposed or had been exposed to talc dust. Of thirty-three men exposed to heavy concentrations of dust, eight were found to have pneumoconiosis grade 1, and eight to have pneumoconiosis grade 2 or 3. He could not attribute the high tuberculosis mortality rate in the county to the talc industry.

Kronenberg,[28] in 1937, called attention to the danger to nurses using talc to prepare gloves for surgery, and urged proper care so that the nurses need not breathe injurious quantities of this powder. In his report he stated that he found dangerous concentrations of the powder from air samples taken near the breathing zone of the nurses.

In 1942, Porro, Patton, and Hobbs[29] called attention to the danger of pneumoconiosis in the talc industry, and reported fifteen cases in talc workers. These included five autopsies. He stated that the pneumoconiosis causes disability, but that death did not result directly from this cause in talc workers. The tissue changes were due to talc itself.

Schulz and Williams,[30] in discussing commercial talc, found that lesions were present only in the organs where talc had been deposited. Progressive fibrosis, such as produced by crystalline-free silica, was not observed. The fibrosis which does occur is only to hold and limit the space for storing of foreign material.

In 1935, Bethune[31] suggested the use of talc as a means of artificially creating adhesions around the lung so that it would remain in position during re-

section. He was able satisfactorily to produce adhesions using an iodized talc blown in with a special blower. Ten months after the first clinical patient was operated upon, he observed no ill effects from the presence of this insoluble powder between two pleural surfaces.

In 1940, Thompson[32] suggested talc to produce pericardial adhesions. He said: "From our experiments with animals, it was found that placing talcum powder in the pericardial sac would produce an adhesive pericarditis, which, in turn, would furnish collateral circulation adequate to overcome a deficiency of blood supply to the heart following ligation and diversion of a main branch of the coronary artery. On the basis of this experiment, ten patients with coronary artery disease have been operated upon. Although two have died, and one patient has been operated upon too recently to evaluate the recovery, seven have received very marked benefits."

In 1946, Lichtman and co-workers,[33] working at Rochester, Minn., presented evidence to show that extensive tissue damage may be caused by talc. Granulomatous lesions of the peritoneum, draining sinuses, scar nodules, and malfunctioning intestinal stomas were found at secondary operations. Talc implanted intentionally around fistulas in dogs caused persistence of the fistulas. They observed that in human beings the tissue reacts by forming pseudotubercles and they believe that, as Lycopodium powder has been removed from use in the operating room, talc likewise must go. It was their impression that talc granulomas would be recognized more frequently if there were greater use of polarized light microscopy.

Lee and Lehman,[34] in 1947, contrasted the physiologic effect of talc with that of a powder similar to the one used in this investigation. Their work substantiated the previous reports that have been published emphasizing the irritative lesions caused by talc. They found that this new nonirritating powder (starch powder No. 108)* was completely absorbed by the peritoneum without inflammatory reaction and without the formation of adhesions.

The absorbable starch powder (No. 108) with which we have been working for approximately one year, and with respect to which our findings are presented in this paper, is the same material used by Lee and Lehman[34] and Lindenmuth.[35] It consists of a mixture of amylose and amylopectins, derived from cornstarch, which has been treated by physical and chemical means to improve its lubricating value and to prevent gelatinization when autoclaved.

The first portion of our investigation was an allergenic study to determine whether human beings could have become previously sensitized to this or similar starches. We also attempted, by means of parenteral injections, to sensitize animals.

The second section of the study consisted of injecting powder No. 108 intraperitoneally and subcutaneously in rabbits and guinea pigs, and intraperitoneally alone in dogs, to observe its effect. These particular experiments

*For the sake of convenience, starch powder No. 108 has been given the trade name of Bio-sorb.

were also contrasted with similar experiments on animals, using talc. The talc experiments were carried out to confirm previously reported work on the use of this powder.

The third portion of our work consisted of inhalation experiments in which rabbits were exposed to atmospheres of talc and of powder No. 108 under the same conditions.

Studies were made to determine existence of a previously acquired sensitivity to this starch. Patch tests were made on fifty adult males. The tests were applied and left in place for seventy-two hours with readings recorded at the end of twenty-four, forty-eight, and seventy-two hours. No positive reactions were obtained.

An extract was made of this starch in the manner used to prepare allergens for use in the allergy department. Eighty-one patients with allergenic backgrounds in the allergy clinic at the University of Nebraska were tested both by scratch and by intracutaneous tests. No reactions were found in this group. In so far as our results go we could not find that a previous sensitivity to this starch existed.

In the rabbits in which parenteral inoculations of the starch had been done, ophthalmic tests were made from time to time, and at no time was a positive reaction obtained. Ten virgin female guinea pigs were given injections of 0.5 Gm. of the starch. At the end of fourteen days strips of uterine muscle were removed and tested by the approved methods for sensitivity. Testing with extracts of the starch, no contractions were elicited. Histamine and Pituitrin used on the same muscle proved its contractibility. We were not able to sensitize rabbits and guinea pigs with powder No. 108.

As a matter of interest in further confirming the excellent work of Lee and Lehman,[34] a laparotomy was performed on a medium-sized dog under strict surgical technique and 1.0 Gm. of the absorbable powder was dusted over the intestines and omentum. The dog was allowed to survive for three weeks and the abdomen again opened. No adhesions were found, and we were not able to detect any of the starch.

A similar operation was performed on another dog but, instead of using the absorbable powder, 1.0 Gm. of talcum powder was dusted over the intestines and the omentum and the wound was closed. This dog was sacrificed at the end of three weeks. Almost the entire peritoneal cavity was covered with adhesions. Sections taken from these adhesions also showed talc.

Under general anesthesia, the peritoneal cavities of two rabbits were opened and 0.5 Gm. of powder No. 108 was placed within. At the end of twenty-four days the rabbits were sacrificed; no adhesions were found, and we were not able to detect any of the powder. Under similar conditions two rabbits were operated upon but 0.5 Gm. of talc was used in place of the absorbable powder. At the end of twenty-four days these rabbits were sacrificed and the peritoneal cavities were found to contain massive adhesions. The general picture was the same as that in the dog (Figs. 1, 2, 3 and 4).

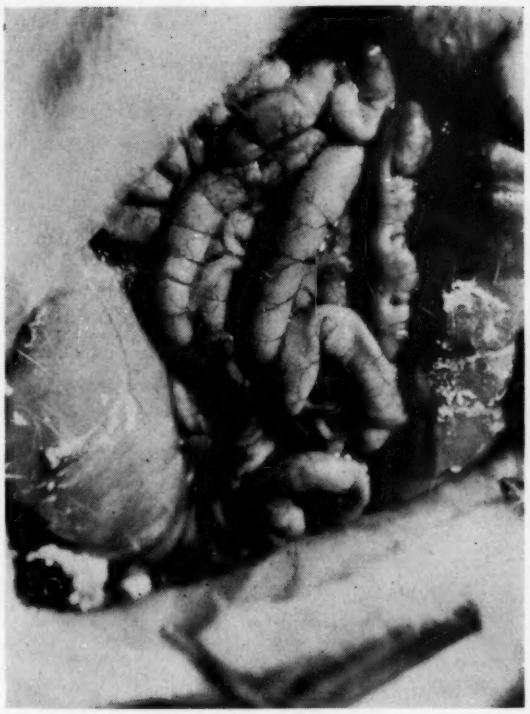
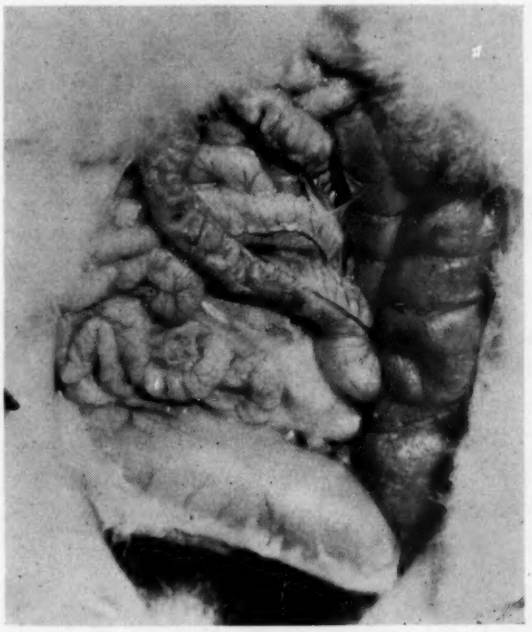


Fig. 1.—Peritoneum of rabbit, three weeks after introduction of talc; many collections of talc may be seen, and several adhesions are evident.

Fig. 2.—Wall of bowel (×120) after use of talc, under polarized light, partial extinction. The subserosa has been greatly thickened by fibrosis and granuloma formation. White spots are talc granules.



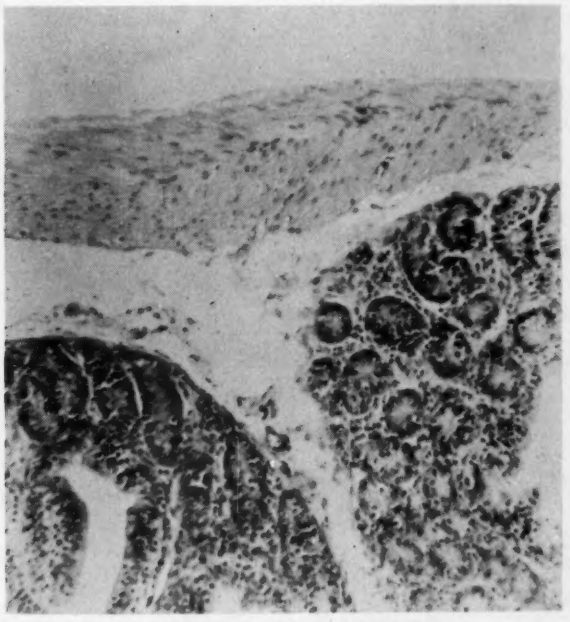


Fig. 3.—Peritoneum of rabbit, three weeks after introduction of powder No. 108; surfaces are smooth and free from adhesions.

Fig. 4.—Wall of bowel (×120) after use of powder No. 108; the serosa is not changed, and no fibrosis or inflammation has occurred.

The absorbable starch powder under investigation was made into pellets weighing 200.0 mg. These pellets were placed subcutaneously in the interscapular region of twenty-five rabbits. The pellets were allowed to remain in ten rabbits for fourteen days, in ten rabbits for twenty-eight days, and in five rabbits for fifty-six days. The impression from these studies is of a persistent activity, but not intense reaction to the presence of the material, and very little, if any, of the material was to be found at the end of fifty-six days. It should be pointed out that this is a very severe test since absorption of a fairly hard pellet of material from the subcutaneous tissue would be expected to proceed slowly.

In line with the studies of Lindenmuth,[35] 500 mg. of powder No. 108 were injected intraperitoneally into the abdomen of each of ten guinea pigs. These guinea pigs were allowed to survive for fourteen days and then were autopsied; no adhesions or other evidences of irritation were found.

Since the inhalation of mineral dusts is potentially dangerous, and to obtain information with respect to the reactivity of the experimental powder in lung tissue, six rabbits were subjected to an inhalation experiment in which they were placed in an enclosure approximately four feet in diameter and two feet high, and a heavy concentration of powder No. 108 was kept in atmospheric suspension by means of a circulating fan. These animals were exposed forty minutes a day for fifty days. At the end of this time the animals were sacrificed; no lung pathology could be demonstrated.

A similar experiment was carried out with two rabbits, using talc instead of the absorbable powder. The lungs of these rabbits showed scattered silicate particles with some giant-cell formation.

CONCLUSIONS

1. We were unable to find any sensitivity to this starch in the group of human beings tested.

2. We were unable to prove that the animals became sensitive when injected parenterally with this absorbable powder.

3. No peritoneal adhesions occurred in any of our animals in which powder No. 108 was used.

4. Our work shows that a chemically modified starch powder (No. 108), when placed in the tissue of animals, is nonirritating and is readily absorbed from the peritoneal cavity.

5. Our work confirms that of previous authors that talc is irritating when placed in the peritoneal cavity of dogs and rabbits, and in the lungs of rabbits.

6. The evidence indicates that powder No. 108 is a safe replacement for talc for surgical and other purposes for which this commodity is widely used.

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THE MAGNUSON-STACK PROCEDURE FOR RECURRENT DISLOCATIONS OF THE SHOULDER

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THE multiplicity of procedures described for repair of recurrent traumatic subcoracoid and subglenoid dislocations of the shoulder is ample evidence that no procedure has yet proved completely successful. During the last few years two procedures have held out more hope for permanent reduction; one is the Bankart[1] operation of repair of the capsule, and the other the Magnuson-Stack[2] procedure of transportation of the tendon of the subscapularis from the lesser to the greater tuberosity of the humerus. The author is concerned with the latter procedure, and wishes to report a follow-up study of thirty-one such operations which vary in follow-up from three years to one and one-half years. It is conceded that the length of time elapsed is insufficient for a complete and final analysis, but it is hoped that this report will serve as an added impetus for more bone and joint surgeons to use this procedure. It appears to be quite promising, and only by reviewing a large series of cases, at least five years after surgery, can any definite conclusions be reached.

The incentive for the use of the Magnuson-Stack procedure in preference to other operative techniques has been based on the following observations. It was noticed that the Nicola[3] procedure and its various modifications, even when performed by men in the armed services who were capable and qualified, still permitted recurrences to develop in approximately 20 to 25 per cent of the instances. The use of the Henderson[4] suspension was not particularly appealing because the recovery of the average enlisted man and his return to duty diminished in proportion to the number of skin incisions, particularly where elective surgery was concerned. Certainly there are multiple such incisions in the Henderson procedure. Use of the bone peg procedure or of the various fascial and muscle plasties was not particularly advocated in the armed services, due to the long healing time required and the difficulty in mobilizing such shoulders after a prolonged period of immobilization. As for the Bankart procedure, I attempted it on three occasions, and it is admitted that decisions based on three attempts are inconclusive. However, the consensus of opinion of a number of other men who had also attempted the same procedure was that, (1) it was extensive surgery, and with this statement even the exponents of the Bankart procedure must agree, (2) the reattachment of the capsule to the lip of the glenoid process was not the reason for the success of the procedure for the capsule could again be avulsed with sufficient trauma, but rather the amount of scar and adhesions which developed following such extensive dissection, which was unphysiologic, and, (3) the drilling of the holes just posterior to the rim of the glenoid process was not the easiest procedure to perform. Furthermore,

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Magnuson and Stack's[2] reasoning as to the causes of recurrent subglenoid and subcoracoid dislocations of the shoulder and the corrective surgery for this condition sounded more reasonable and convincing.

CAUSES OF RECURRENCE

The exact cause of recurrent dislocations has not been adequately explained. Certainly not all shoulder dislocations recur, and furthermore dislocations have recurred in many patients who have received adequate immobilization after the initial episode. Originally it was thought to be due to a poorly healed tear of the capsule. Another theory propounded was that it was due to the shallowness of the glenoid fossa. Bankart attributed it to a tearing of the capsule at the anterior inferior lip of the glenoid with an avulsion of the capsule with subsequent lack of healing and gapping at the point of tearing. Magnuson has brought forth another line of thought as to the cause of recurrent dislocations, which is, that it is due to "a lack of balance, traction, and leverage of muscles which ordinarily resists the downward and forward displacement of the head." Magnusons's idea is well worth considering. In reasoning out this thought he stated:[5]

> I do not feel that the glenoid, which is very slightly cup-shaped, has much supporting function for the head of the humerus in contradistinction to the acetabulum, which is much deeper and serves as a weight-bearing structure. There are no such ligaments in the shoulder capsule as are in the hip, where the Y-ligament acts as a strong reinforcing band to resistance of hyperextension of the hip. The shoulder muscles are the only structures which maintain the head of the humerus in contact with the glenoid and in proper position. This is plainly evident, for if these muscles are paralysed, the head of the humerus will drop away from the glenoid and may lie clear below it. That is not true of the hip; even if the muscles between the pelvis and the femur are completely paralysed, the hip will not easily dislocate and certainly will not drop as a result of the drag on the leg. Patients who have had infantile paralysis and have a subsequent fracture of the leg must have traction applied. Never have I seen a hip pulled out of the acetabulum, but I have seen the head of the humerus pulled away from the glenoid as a result of improperly applied traction to the humerus. When the shoulder muscles are relaxed, it takes very little pull to separate the head of the humerus from the glenoid, and if traction is left on for a few hours, it is not difficult to create as much as a half inch separation between the faces of the joints.

Certainly such reasoning cannot be cast aside as simply another theory even by the most ardent exponents of the Bankart procedure, who claim that the reason for recurrence was the avulsion of the capsule from the glenoid labrum. Furthermore, tear of the capsule was not found to be present in all of the shoulders which were exposed in this series. If, as Bankart contends, the cause of the recurrent dislocation is the shallow glenoid and the tear of the capsule, then what is to prevent a future recurrence of the tear of this capsule if sufficient trauma should be applied?

THE OPERATION

The operation was designed to meet and counteract certain conditions which Magnuson and Stack believe exist in recurrent shoulder dislocations.

Ordinarily the subscapularis tendon is broad and strong and blends with the capsule of the shoulder, thus reinforcing the capsule in this region and tending to counteract the pull of the strong adductors, namely, the pectoralis major, the teres major, and the latissimus dorsi (Fig. 1). If, on the other hand, the tendon of the subscapularis is thin and narrow or if it does not blend fully with

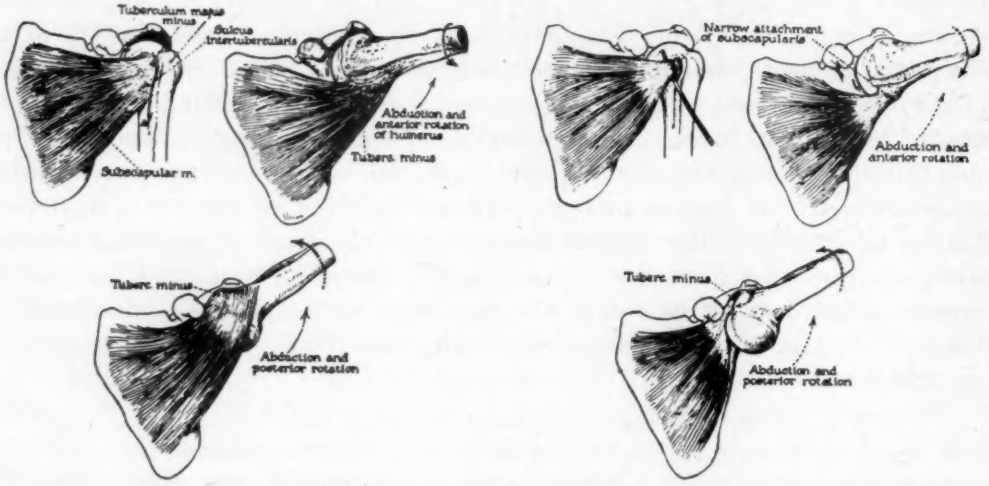


Fig. 1.—Attachment of subscapularis to lesser tuberosity of humerus. (Figs. 1 to 5 from Magnuson and Stack, J. A. M. A. December, 1943.[2])

Fig. 2.—Tendon slipping between head of humerus and coracoid when arm is placed in abduction and extension.

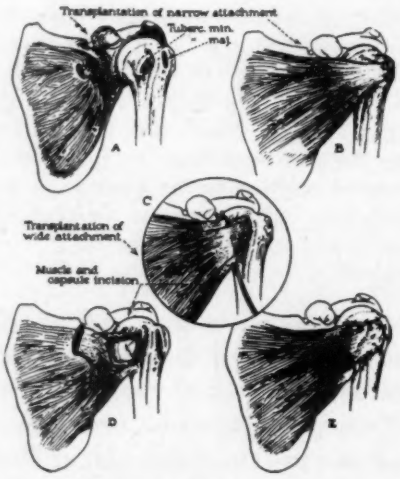
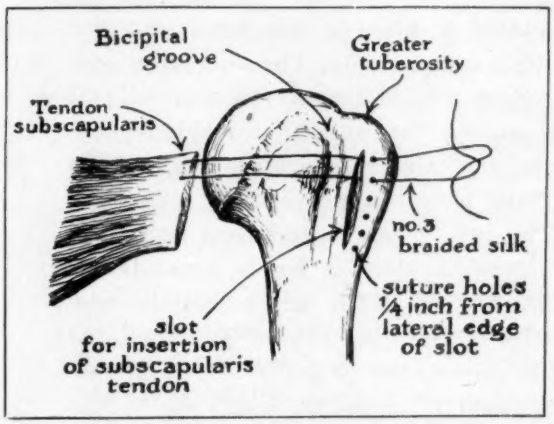


Fig. 3.—Medial reflection of tendinous attachment and exposure of head of humerus.

the capsule, then the space between the subscapularis tendon, which latter attaches to the lesser tuberosity, and the supraspinatus, infraspinatus, and teres minor muscles, which attach to the greater tuberosity, is so increased as to permit the head to dislocate downward and forward between these two groups of muscles (Fig. 2). The abnormality of a loose tendon, and therefore slipping

of this structure in between the head and the coracoid was not seen in any of the series of cases reported here. The tendon was found to be quite thin and narrow in a number of instances.

The operation, therefore, was designed to overcome this weak point in the musculotendinous cuff by transplanting the subscapularis from the lesser to the greater tuberosity (Fig. 3), thus forming a musculotendinous cup around the anterior surface of the head of the humerus which is controlled by the subscapularis, which reinforces the capsule in the region of the insertion of the supraspinatus, infraspinatus and teres minor, and which overcomes the spread which exists ordinarily (Fig. 5).


Bicipital groove
Greater tuberosity
Tendon subscapularis
no. 3 braided silk
suture holes ¼ inch from lateral edge of slot
slot for insertion of subscapularis tendon

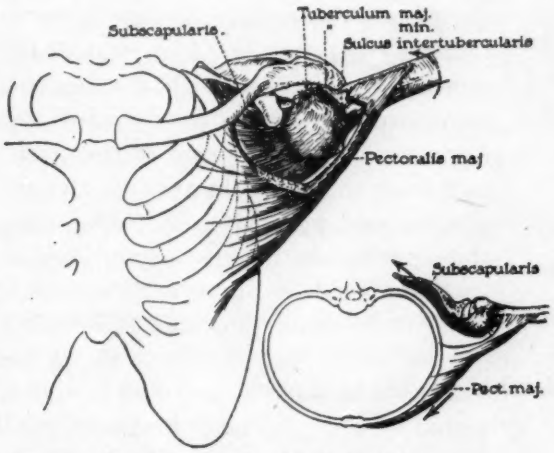


Fig. 4.—Method of application of braided silk No. 3 suture to draw tendon into slot.
Fig. 5.—Tendon and muscle of subscapularis winds firmly around head of humerus.

OPERATIVE PROCEDURE

A four to five inch incision is made on the anterior aspect of the shoulder beginning just below the acromioclavicular joint and extending distally parallel to the fibers of the deltoid. The muscle fibers are split at the region of the anterior and middle thirds exposing the capsule. Bleeding is controlled by the use of the coagulating current, which latter is quite an efficient and certainly a time-saving device. The extremity is externally rotated thus bringing into view the tendon and the musculotendinous junction of the subscapularis. A blunt dissector is then slipped under the musculotendinous junction just lateral to the area where the tendon blends in with the capsule, the dissector being inserted at the lower border and coming out at the upper border. This portion of the structure is easily identified and requires very little sharp dissection. Traction is then applied by lifting up on the blunt dissector, thus bringing into relief the insertion of the muscle into the capsule and also the upper and lower borders of the tendon where they blend to the capsule (Fig. 3). The incision is made along the upper and lower borders of the tendon through the capsule, the scalpel is then slipped under the tendon and the tendon and capsule are then incised, thus freeing these structures to the area of their insertion into the lesser tuberosity.

During the first three or four operations an attempt was made to free the tendon from the capsule, but it was found to be almost impossible, and furthermore the tendon itself was much thinner and thus a weaker structure. Magnuson and Stack in their procedure then recommended removing a wedge-shaped piece of bone at the insertion of the tendon, for transposition into the greater tuberosity. This step has not been followed. Instead, the tendon is detached from the lesser tuberosity, a suture is passed through it so that it can be brought into the field whenever necessary, and the extremity is then internally rotated to bring the bicipital groove and the greater tuberosity into view. The joint can be inspected at this time and any tear of the capsule noted. After the arm has been internally rotated, the tendon is pulled across the bicipital groove to the greater tuberosity to determine the new location of the tendon. During this time the arm should be externally rotated to observe how much external rotation is permitted with the tendon in its new position. The amount of external rotation should never be less than 50 per cent of the normal amount and not more than 75 per cent of the normal amount. Two thin-bladed chisels, one-half inch wide, should then be driven into the greater tuberosity next to one another and parallel to the outer edge of the bicipital groove, thus forming a slot approximately one inch in length. The two chisels should then be rocked back and forth in opposite directions to widen this slot. A heavy, small tenaculum or a towel clip should be used to make six holes approximately one-quarter of an inch lateral to the lateral edge of the slot. Three No. 3 braided silk mattress sutures are used to immobilize the tendon (Fig. 4). They are inserted through the most proximal hole out through the slot, through the tendon from the dorsal to the ventral surface up through from the ventral surface to the dorsal surface through the slot, and out through the second hole. After all three sutures have been placed, they are drawn tightly, thus pulling the tendon into the slot, and are tied securely. The upper and lower borders of the tendon are then sutured to the surrounding capsular structure with interrupted No. 40 white cotton sutures so that there will be no tendency of the tendon to slip up toward the coracoid process when the arm is held in a position of abduction. This part of the procedure is very important, for it is felt that the two failures which occurred in this series are due to the fact that this step was not carried out in either instance. The arm should again be externally rotated and if the operation has been properly performed, there should be no more than a 50 per cent limitation of external rotation. The deltoid fibers are allowed to fall back into place, and the soft tissues are closed in the usual anatomic manner. The upper extremity is then immobilized against the chest using a Velpeau bandage.

The period of absolute immobilization is three weeks. At the end of this period of immobilization active and passive exercises are instituted in the form of pendulum exercises actively, three times daily for ten minutes, and gentle external rotation passively once daily by the physiotherapist. Active external rotation and abduction were not instituted until the end of six weeks, at which time these motions are included in the daily exercise routine. At the end of eight weeks the average patient has almost complete range of all motions, except for external rotation which is usually limited to about 110 degrees of the normal, the normal being between 130 to 140 degrees.

ANALYSIS

Thirty-one shoulders were operated upon in thirty patients. All had had a minimum of at least three, and usually five, dislocations, and quite a number of them had lost count of the number of dislocations. In one patient the shoulder dislocated whenever it was abducted beyond 90 degrees. Twelve months after the operation he passed a West Point physical examination. Another patient stated that his main concern was that the shoulder dislocated in his sleep as frequently as twice a night. The maximum follow-up has been three years, and the minimum one and one-half years.

Avulsion.—In nineteen shoulders, or 60.6 per cent, there was definite evidence found of avulsion of the capsule from the anteroinferior glenoid rim. This was determined by inspecting the shoulder joint when a small section of the capsule was removed along with the tendon of the subscapularis. A blunt dissector was then inserted into the joint the glenoid rim palpated, the tear located, and, when present, inspected. No attempt was made to repair it. In the other twelve shoulders no tear could be found. It was possible to dislocate these shoulders quite easily at the operating table, but no definite pathology could be found other than a general relaxation of the capsule.

Recurrences.—There were only two recurrences to date, or 6.4 per cent. Both of these shoulders dislocated approximately six to eight months after surgery. It is felt, however, that the fault does not lie with the procedure, but rather with the operator. In each of these instances the upper and lower borders of the transposed tendon were not sutured to the surrounding capsular structures, and, therefore, probable slipping of the tendon occurred because of it. It would be interesting to re-explore these shoulders, but to date the patients concerned have been unwilling to submit to further surgery.

Motion.—The primary motion concerned in each instance is, of course, external rotation. As previously mentioned, at the end of eight weeks postsurgery, there was limitation of external rotation in almost all of the patients. At the present writing, however, only eight or 27.6 per cent, had any definite limitation of external rotation. One had a 30 degree limitation of motion. Of the rest, one had 20 degrees loss, and the general average was approximately 10 degrees. However, none of the patients, except the one with the 30 degrees limitation of external rotation, were particularly incapacitated because of this loss, nor did they complain about it. The remaining twenty-one shoulders, or 72.4 per cent, had a trace or no limitation of external rotation, and it was less than 10 degrees in comparison to the opposite shoulder. Abduction through the scapulohumeral joint, which is the next important factor to consider, was limited in five patients. The maximum loss was 45 degrees in one patient, 25 degrees in another, and 15 degrees in three patients. Two patients showed a loss of forward extension—15 degrees in one, and 10 degrees in the other.

Pain.—Regarding pain upon use of the operated extremity, eight patients reported its presence. One patient who had a recurrence stated that the

shoulder ached constantly. The other seven noticed pain or stiffness only after strenuous use or upon changes in weather. Thus, 77.5 per cent had asymptomatic shoulders.

It is important to remember that this operative procedure was performed on military personnel and that the strenuous use of these shoulders in the armed services is usually far and above the amount required in civilian life. These patients were able to return to limited duty at the end of eight weeks, and at the end of three months all were able to return to full duty, except for three patients who had continued symptomatology of the operated shoulder, and in two of these the shoulders subsequently dislocated. In the follow-up study from the reports solicited from the patients and their physicians, the majority of these men had been able to carry on a full day's work without any difficulty whatever. Some are able to ski and perform other strenuous physical activities without any difficulty. One patient proudly wrote that he was able to chin himself fourteen times on a chinning bar in spite of the operated shoulder.

CONCLUSIONS

1. The Magnuson-Stack Procedure has been successful in 91.6 per cent of the present series of cases, with a minimum follow-up of one and one-half years.

2. In 72.4 per cent there was a trace or no limitation of external rotation.

3. In 77.5 per cent of the patients, the shoulder operated upon was entirely asymptomatic, and the patient concerned was able to perform a gainful occupation.

4. The two postoperative recurrences were not due to failure of the operative procedure, but were due to errors in technique on the part of the operator.

5. The Magnuson-Stack procedure is a well-planned operation, and this report is presented at this time in the hope that others will use this procedure, and thus amass a large enough series of cases within the next five to ten years so that definite conclusions can be reached as to the final value of the operation.

The author wishes to take this opportunity to thank Dr. Edmond Uhry and Dr. Charles A. Hulse, whose able assistance and suggestions have been of great value in performing this work.

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A PLASTER TRACTION SPLINT FOR COMPOUND COMMINUTED FRACTURES OF THE TIBIA AND FIBULA

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THE efficiency of the plaster traction splint described in this communication was evaluated under military circumstances in the 22nd United States Army General Hospital at Blandford, England, and the 97th General Hospital at Frankfurt, Germany, between May, 1944, and December, 1945. During this period we personally used it in sixty-five battle-incurred fractures of the tibia and fibula in sixty-three patients and in eleven simple and compound comminuted accidental fractures of the same bones. During the early months of the same period an approximately equal number of similar fractures, which served, in effect, as a control series, were treated in the Böhler-Braun splint or in the Thomas splint with Pearson attachment. As the advantages of the combination splint, which at first was used only tentatively, became clarified, standard splints were used less and less frequently.

From the standpoint of providing skeletal traction and securing immobilization of the fractures in plaster, the combination splint was found to compare very favorably with the classical traction splints. It was also found to possess several additional advantages. It furnishes better protection for the reduced fractures. It makes movement less painful during the early days of healing. It eliminates the uncomfortable counterpressure of the ischial ring of the Thomas splint and the painful play at the fracture site permitted by the Böhler-Braun frame. It does not require the time-consuming, continuous, expert attention necessary when the Thomas splint with Pearson attachment is used, which made it of particular value during the war when heavy casualties were received. Finally, it proved of great usefulness in patients received more than eight to twelve hours after injury, when internal fixation was contraindicated by the risk of infection or when extensively comminuted fractures of the shaft of the tibia would have required undesirable dissection of the whole leg for the safe application of plates and screws.

The plaster traction splint would seem to be as applicable to compound fractures of the tibia and fibula in civilian practice as it was in military surgery, and it is presented with this thought in view.

The traction splint, which is made of materials in standard supply in all fracture clinics, is constructed and applied as follows (Figs. 1 to 3): A plaster

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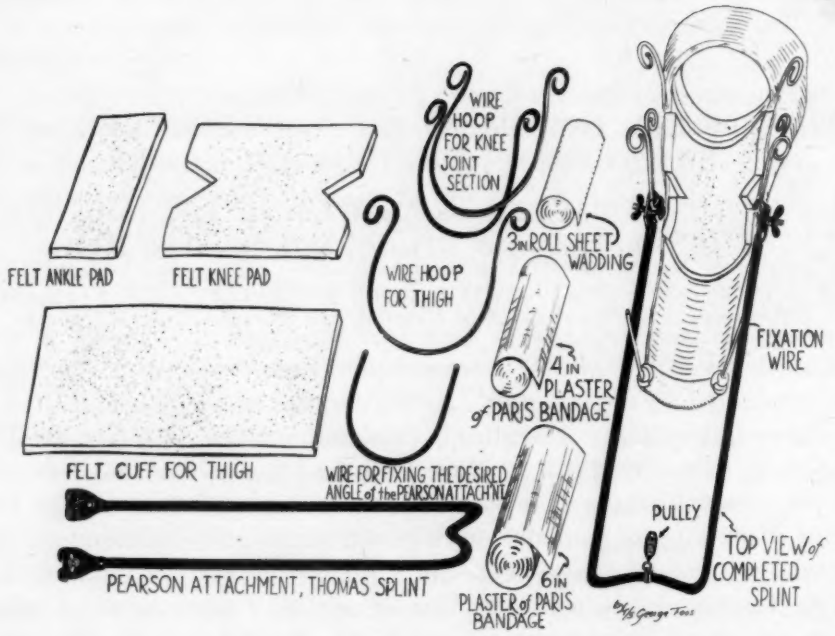
WIRE HOOP FOR KNEE JOINT SECTION
3IN ROLL SHEET WADDING
FELT ANKLE PAD
FELT KNEE PAD
WIRE HOOP FOR THIGH
FIXATION WIRE
4 IN PLASTER of PARIS BANDAGE
FELT CUFF FOR THIGH
WIRE FOR FIXING THE DESIRED ANGLE of the PEARSON ATTACHMT
PULLEY
TOP VIEW of COMPLETED SPLINT
PEARSON ATTACHMENT, THOMAS SPLINT
6 IN PLASTER of PARIS BANDAGE

Fig. 1.—Materials used in construction of plaster traction splint for compound fractures of the tibia and fibula, with interior view, from above, of assembled splint.

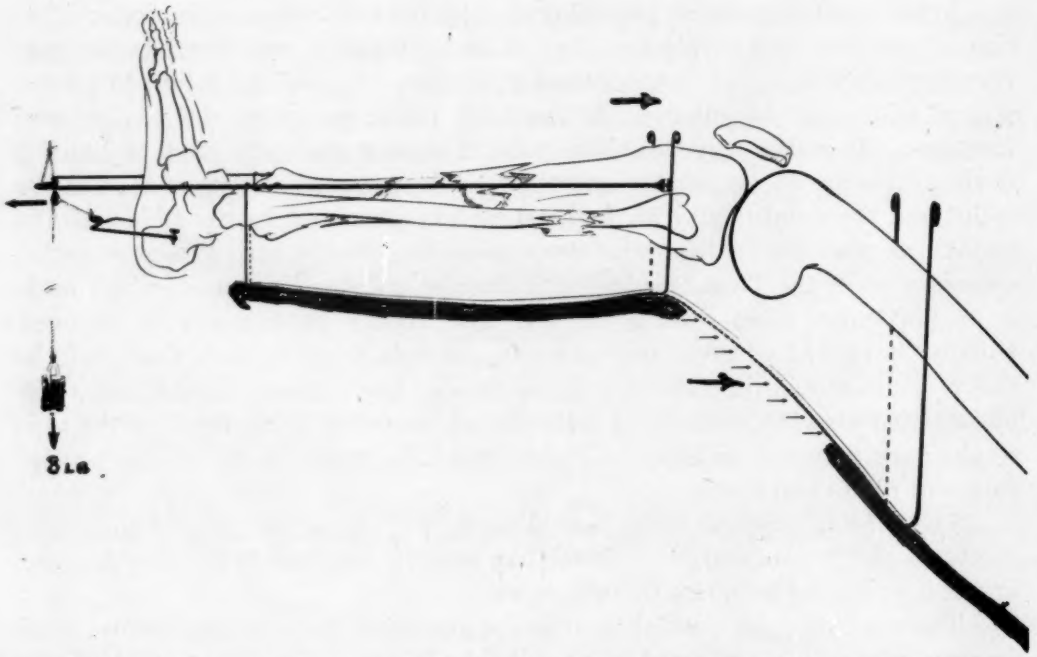

Fig. 2.—Mechanism of action with splint in traction obtained through Pearson attachment incorporated in long leg plaster cast. The countertraction is mainly from a hoop to which the Pearson attachment is clamped at right angles, and also, but slightly, from the ventral aspect of the cast around the thigh.

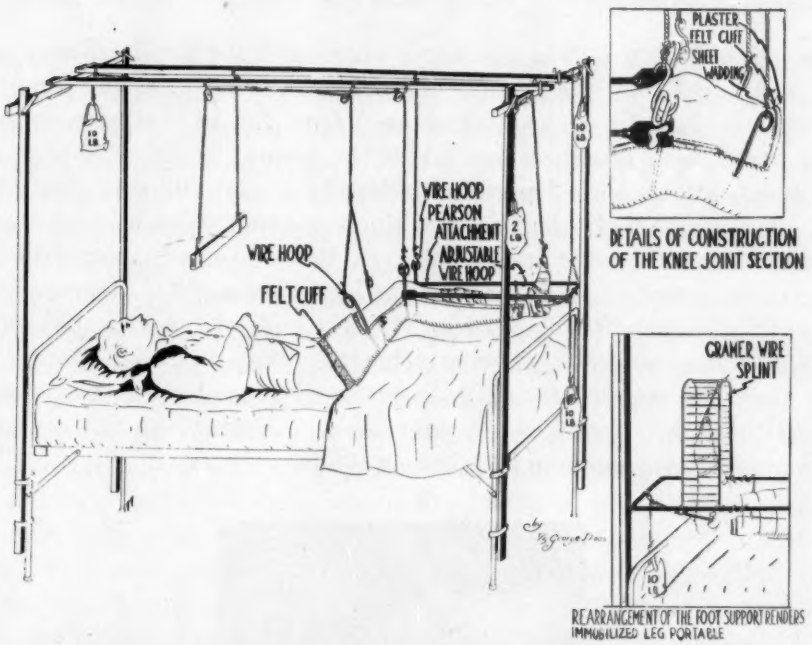

Fig. 3.—Diagrammatic showing of method of suspension of splint and use of trapeze by which patient can lift himself off bed and aid in his own nursing care. Details of construction of the knee joint section are shown in upper right insert. Method of mobilizing splint and adding foot support is shown in lower right insert.

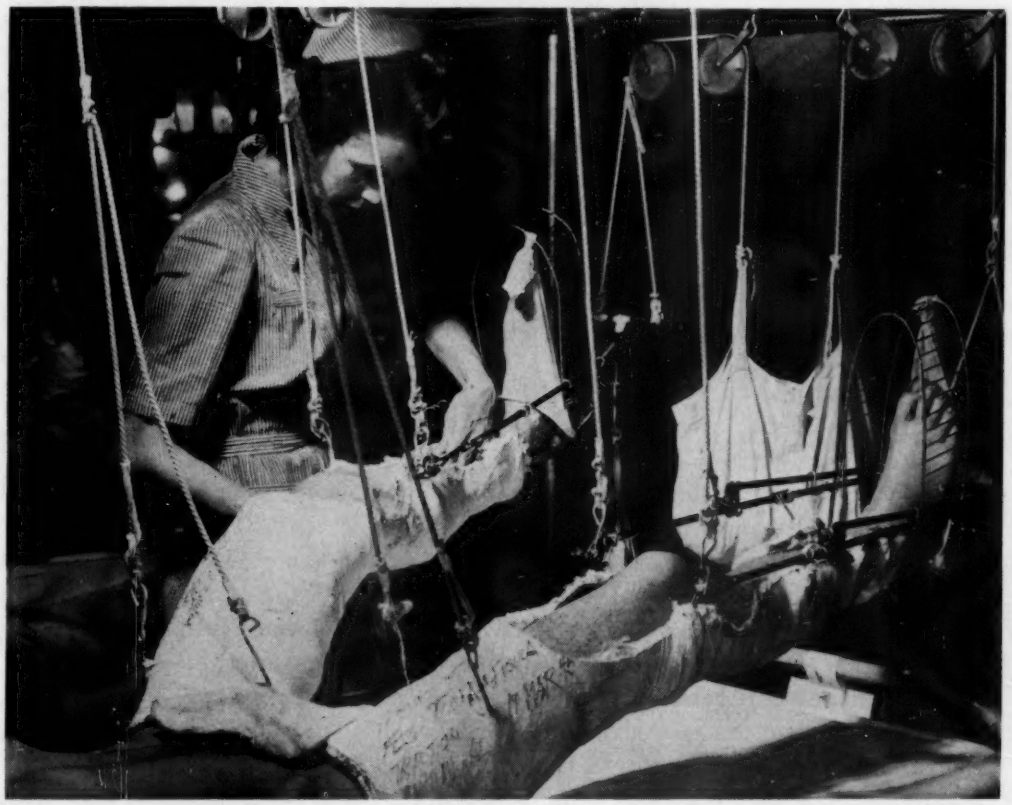

Fig. 4.—Traction splints applied for bilateral compound fractures of tibia and fibula. The wounds were closed by delayed suture seven days after the splints had been applied. The physiotherapist is supervising early muscle-setting exercises during third week of healing.

cylinder, padded with felt in the upper thigh and the popliteal and malleolar regions, is applied from the groin to the ankle while the knee and hip are flexed 45 degrees. U-shaped wire hoops, fashioned from No. 12 iron wire, or any other available metal rod, are incorporated in the plaster at the midthigh and the malleolus, so that the closed portion circles the lateral and posterior aspects of the leg. Two similar wire hoops (or a single heavier metal hoop) are similarly incorporated in the plaster at the knee. A Pearson attachment, with a pulley fastened to the crossbar, is placed over the leg in the sagittal plane and clamped in place to the hoops at the knee (Fig. 1). The ends of the wire at the malleolar level are wound about the Pearson attachment. The anterior portion of the cast between the open ends of the hoop is cut away from the superior pole of the patella to the ankle, and windows are cut, if necessary, on the posterior and lateral aspects to give access to soft tissue wounds.

Fig. 5.—Patient in traction splint after overhead suspension has been discontinued.

A suitable weight is attached and traction is applied with the leg suspended in a Balkan frame (Figs. 3 and 4). The foot is supported by a stockinet or moleskin sling fastened to a loop of Cramer wire attached to the long bars of the Pearson attachment. When minor corrections in alignment become necessary, the distal fragment can be moved up to 10 degrees in the sagittal or coronal planes by shifting the pulley from side to side and elevating or lowering the end of the Pearson attachment.

Overhead suspension is continued during the first two weeks of healing, when the nursing ritual, including the bath and the use of the bedpan, are painful undertakings. As healing progresses, overhead suspension is discontinued and the patient is allowed more freedom in bed. At the end of three to five weeks, when movement is practically painless, he can be placed in a wheel chair (Fig. 5). At the end of six weeks, when callus formation is usually adequate or the fracture site is sufficiently stable, traction can be discontinued and the extremity transferred to a long leg cast, after which ambulation on crutches is instituted as rapidly as possible.

The treatment followed in fractures on which this apparatus was used in World War II is applicable to similar civilian injuries. Thorough débridement was done and the wound was closed by primary suture if the patient was received within eight hours of injury and if damage to the soft parts had not been too extensive. If he was received after this period, the wound was left open at the initial operation and, in the absence of gross infection, was closed by delayed suture within five days or, later, by grafting.

At the first operation in a general hospital skeletal traction was instituted by the application of a Kirschner wire. In fractures of the upper third of the tibia the wire was inserted about one-half inch above the distal epiphyseal line of the tibia. In fractures of the middle and lower thirds it was inserted through the tuberosity of the os calcis, in line with the posterior margin of the fibula. A small Steinmann pin was used in some cases, with complete satisfaction. It was soon found that it was essential to insert the wire or the pin at an exact right angle to the weight-bearing line, without tension on the soft tissues, and with the limb in the position it was to occupy in the completed splint. If these criteria were not met when the wire was applied, it was withdrawn and reapplied. Lack of care in these respects was responsible for several instances of pin seepage and sepsis.

The fractures were reduced by traction and manipulation and held on a fracture table, with the hip and the knee each at 135 degrees. The tautening bow of the Kirschner wire served as a useful handle on the distal fragment for manipulation purposes and was fixed to the footpiece of the table after the reduction had been secured. With this arrangement the position of the reduced fracture was secure while the plaster bandage was being applied and traction was being established.

SUMMARY

1. A combination plaster traction splint is described which was used for simple and compound comminuted fractures of the tibia and fibula during World War II. It proved as effective as classical traction splints in providing skeletal traction and securing immobilization, and it was found to possess several additional advantages which other splints lack.

2. It is believed that this splint is as applicable to simple and compound comminuted fractures of the tibia and fibula in civilian practice as it was to battle-incurred fractures.

SUBCUTANEOUS RUPTURE OF THE BRACHIORADIALIS MUSCLE

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AFTER an exhaustive review of the literature, it is evident that subcutaneous rupture of the brachioradialis is probably hitherto unreported. Other muscle rupture is, of course, very common. It may result from excessive tension or from direct trauma, especially if the muscle involved in under voluntary tension at the time. The most common point of rupture is at the musclotendinous juncture, but the rupture may occur at the muscle's origin, at its insertion, or across its belly. Common predisposing factors are: (1) diseases, such as the acute generalized infections, local tumor, local trauma, trichinosis, and local infections; (2) previous wear and tear; and (3) age, with attendant muscle brittleness, inelasticity, and associated arthritis. Certain occupations provide the second factor of wear and tear. Hence, in plasterers, one sees rupture of the long head of the biceps; in drummers, rupture of the extensor pollicis longus; in climbers, rupture of the Achilles tendon; in loaders, rupture of the muscles of the neck; and in horsemen, rupture of the adductors of the thigh. Other ruptures not infrequently encountered are that of the extensor tendon of the finger at its distal insertion, the so-called "mallet finger," those of the supraspinatus tendon, of the rectus abdominis muscle, the gastrocnemius, and the quadriceps. All these muscles have in common one characteristic, the constant liability of great strain while in a state of voluntary contraction.

This characteristic is not possessed to a great degree by the brachioradialis and this fact probably explains its relative immunity of this injury. The muscle is the most superficial on the radial side of the forearm; it arises from the upper two-thirds of the lateral supracondylar ridge of the humerus, from the lateral intermuscular septum, and from the lateral humeral epicondyle. Fibers from the large muscle belly end above the mid-forearm in a flat tendon which is inserted into the lateral side of the base of the styloid process of the radius. It is apparent that supination, while undoubtedly induced to some degree by the muscle, is not its major function, and that the name "supinator longus" is, for this reason, misleading. Actually, the muscle's primary function is flexion of the radius on the humerus and is most efficiently undertaken with the forearm in the neutral position between supination and pronation, that is, with the radial side of the forearm faced directly upward.

CASE REPORT

R. B., on Jan. 29, 1947, caught the right hand and forearm and elbow between a rotary conveyor belt and the drive wheel of a machine he was operating. He sustained a mild abrasion of the forearm, but rapidly developed a tremendous hematoma of the entire arm. There was no evidence of nerve injury, and x-ray examination showed no fracture. The patient was kept in the hospital for three days, the arm being wrapped in grease dressings and kept constantly elevated. He was then allowed to go home, heat, a sling, and medication

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for the relief of pain being prescribed. He remained away from work for about two weeks, at the end of which time the arm was very much improved in appearance, and entirely asymptomatic. The patient returned to light work and after about two more weeks the swelling had subsided sufficiently for there to be apparent a gap in the brachioradialis at approximately the point where it normally joins its tendon. The patient complained of weakness in the whole forearm, but particularly weakness of flexion. On March 2, 1947, the forearm was explored under pentothal anesthesia. An Esmarch tourniquet was applied and a vertical incision made over the body of the brachioradialis. The deep fascia was incised, revealing a serum-filled cavity between the rounded, retracted, annealed belly of the brachioradialis and the scarred adherent tendon. The rounded belly was freed from the interosseous membrane and adjacent structures, care being taken to preserve the radial artery running along its medial border. The muscle belly was unfortunately nearly devoid of fascia. The

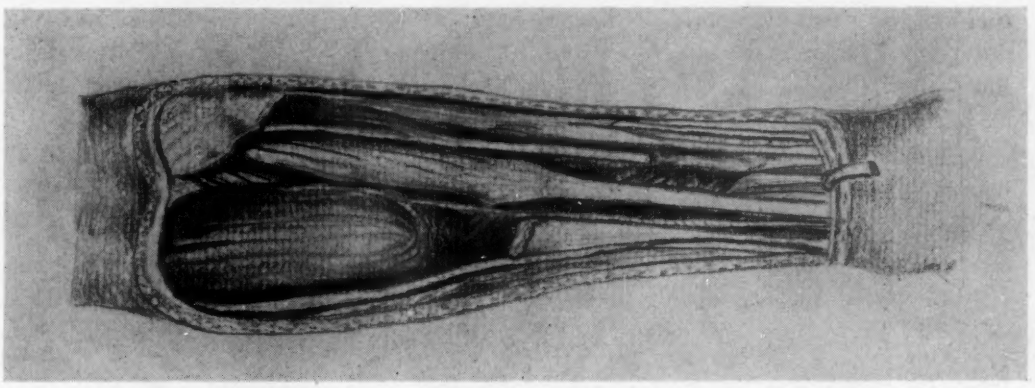

Fig. 1.

tendon was dissected up, its proximal scarred tip was excised, and the tendon itself divided vertically in the midline. With deep chromic catgut sutures the muscle belly was sutured into the tendinous V thus formed. The fascia, subcutaneous tissue, and skin were closed with fine catgut, a petrolatum gauze dressing overlain with sheet cotton applied, and the arm encased from axilla to wrist in plaster, the elbow at right angles, the forearm in supination. The case remained on for four weeks, at the end of which time the wound was well healed. The patient began active motion upon being released from plaster, and at the end of twelve weeks had normal motion and apparently normal strength in the involved arm.

In review, two possible mechanisms by which this muscle was ruptured are apparent. Either the original trauma, with the voluntary effort on the part of the patient to release himself, ruptured the muscle directly, or, following trauma, muscular hemorrhage, and partial recovery, the patient, on resuming light work, subjected the weakened muscle to sufficient strain to bring about its rupture.

FOUR METACHRONOUS MALIGNANT LESIONS OF THE COLON

An Unusual Case

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SIMULTANEOUS involvement of the large intestine by two or more malignancies, usually on the basis of polyposis, has been given its full share of publicity, with the consequence that concomitant lesions are usually recognized and dealt with at the one appropriate time.[1-3] Metachronous lesions may be viewed more leisurely in that each provides a new train of symptoms with no incident between. Interest in the case to be reported lies in the absence of polyposis, the survival of the patient for nineteen years between the first and the fourth lesions, and his resumption of professional activities, limited only by his age, following the most recent resection.

A somewhat similar case, in which four resections were performed within a period of five years, presents features which suggest overlap of consecutive lesions.[4]

CASE REPORT

The patient was a practicing physician, 79 years old at the time of this communication. Subjective evidence of gastrointestinal disturbance first manifested itself in 1926.

First Lesion.—The patient was admitted to Maryland General Hospital on May 3, 1927. He gave a history of general abdominal distress with much flatulence and increasing difficulty with the bowels for one year. For six weeks before admission there had been a dragging sensation in the abdomen and cramps in the left lower quadrant, most noticeable during defecation. Small amounts of blood were occasionally seen in the stool. Abdominal palpation revealed a mass in the left lower quadrant. There was no distention. X-ray studies made prior to admission showed a deformity at the upper end of the pelvic colon. Except for an untransmitted systolic bruit at the apex, the rest of the physical examination was essentially negative.

At operation on May 5, 1927, performed under ether anesthesia, a low left pararectus incision was made and approximately 15 cm. of sigmoid colon, containing a tumor, were removed. The severed ends of the bowel were exteriorized through the original incision. At the time of discharge, on May 25, 1927, the bowel ends were said to be in good condition, draining freely.

Pathologic report (No. 7625, Maryland General Hospital) showed adenocarcinoma. There was no recognizable malignancy in mesocolic lymph glands.

Closure of the colostomy was effected on Oct. 12, 1927, at a subsequent admission, and healing was complete before the end of the year.

Second Lesion.—Because of an attack of nausea and vomiting lasting several hours, followed by persistent constipation relieved only by enemas, a barium study of the colon was performed on June 10, 1935. In the right third of the transverse colon there was a definite obstruction to the progress of the opaque medium, and a tentative diagnosis of neoplasm was made. The patient was admitted to University Hospital on June 18, 1935. At operation, performed two days later, a constricting lesion was freed and exteriorized through an upper right pararectus incision. Complementary cecostomy was performed through a stab wound in the right loin. On June 28, 1935, the tumor mass was removed and a clamp applied to the spur.

The patient was discharged Sept. 4, 1935, with cecostomy and transverse colostomy draining freely. The cecostomy closed spontaneously, and the colostomy yielded some months

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later to the unusual maneuver of insertion of a purse-string suture in the parietes around the stoma.

Pathologic report (No. 25487, University Hospital) revealed adenocarcinoma of colon. The patient came under my observation for the first time on July 14, 1941.

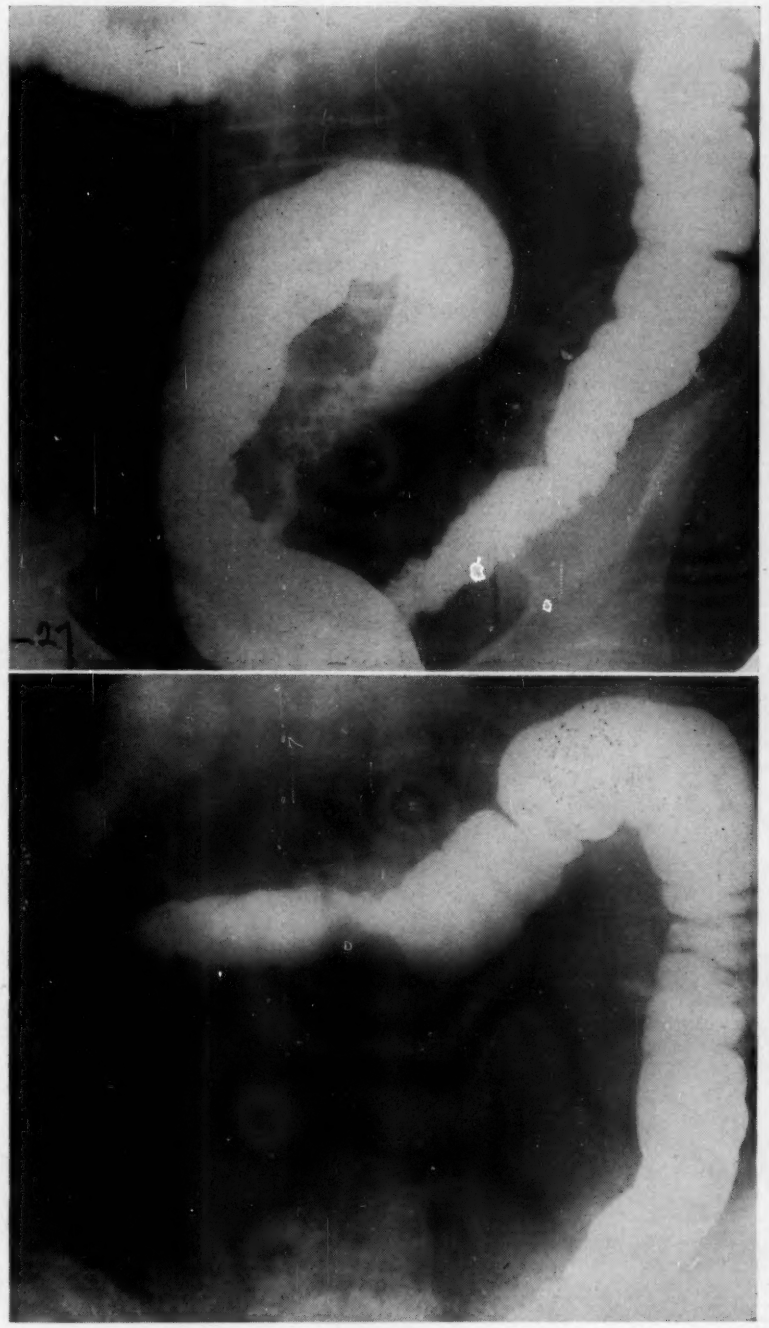

Fig. 1.—Roentgenograms showing filling defects in sigmoid colon of first lesion and in transverse colon of fourth lesion. Other films had been destroyed. (Courtesy of Dr. John Evans, who made all x-ray studies.)

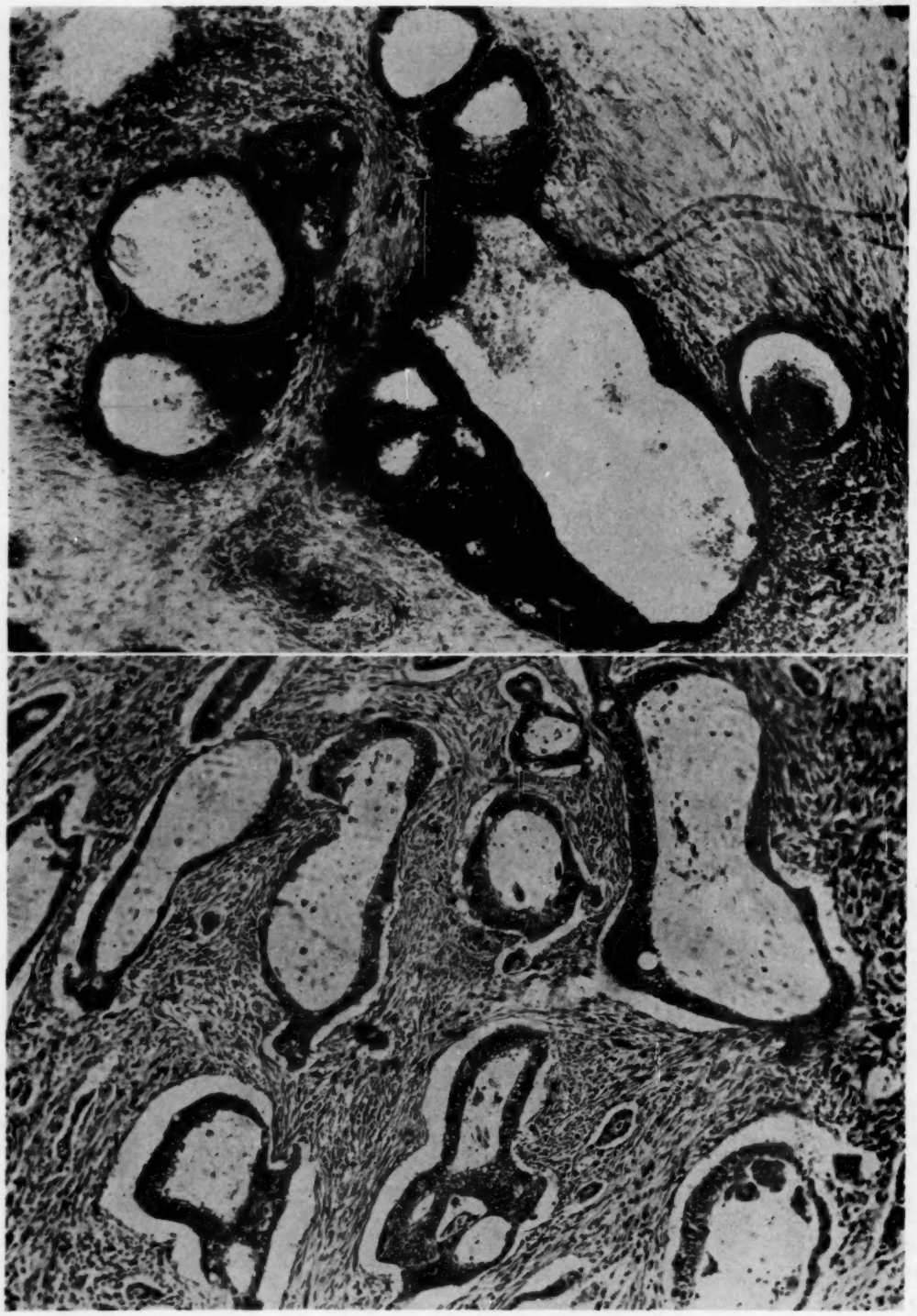

Fig. 2.—Photomicrographs showing cellular structure of first and second lesions.

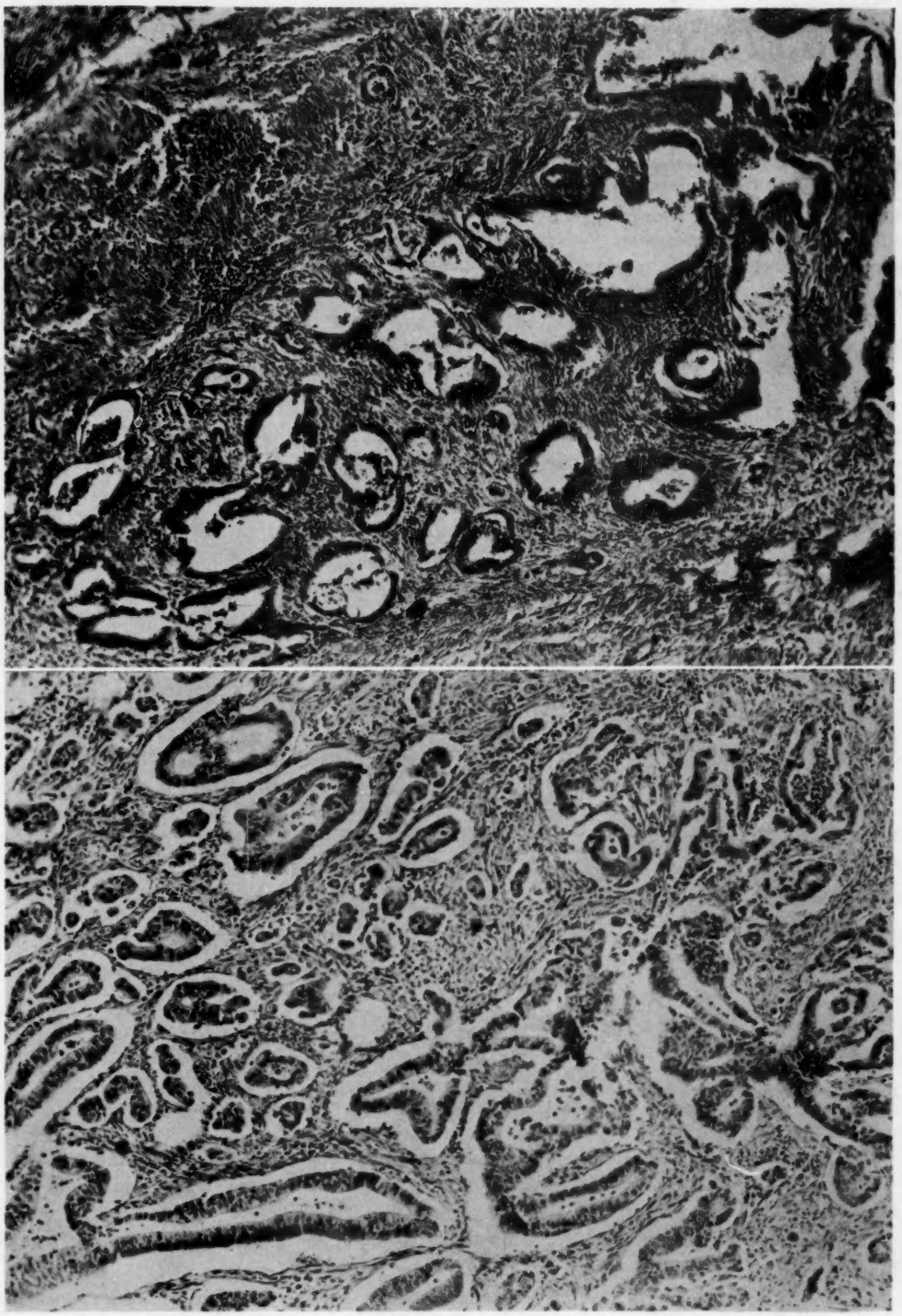

Fig. 3.—Photomicrographs showing cellular structure of third and fourth lesions.

Third Lesion.—For two months prior to admission to University Hospital on July 28, 1941, the patient's suspicions were aroused by a gradual postponement of morning defecation for several hours later than was customary for him. The stools were normal, containing neither gross blood nor mucus. A barium enema performed on July, 10, 1941, showed some delay in the advance of the barium column in the sigmoid, attributable, perhaps, to constriction at the site of the first operation. However, at proctoscopy on July 14, 1941, a well-defined vegetative lesion was seen at 18 cm. from the anus.

On Aug. 5, 1941, following an eight-day sulfaguanidine preparation, laparotomy was performed through a low left paramedian incision. A small, firm mass with slight dimpling on its serosal surface was found 8 cm. above the pelvic peritoneal reflection. Many organized adhesions between omentum, viscera, and parietal peritoneum prevented any attempt at manual exploration. In spite of a previous resection, there remained sufficient sigmoid colon to permit adequate resection and open end-to-end anastomosis.

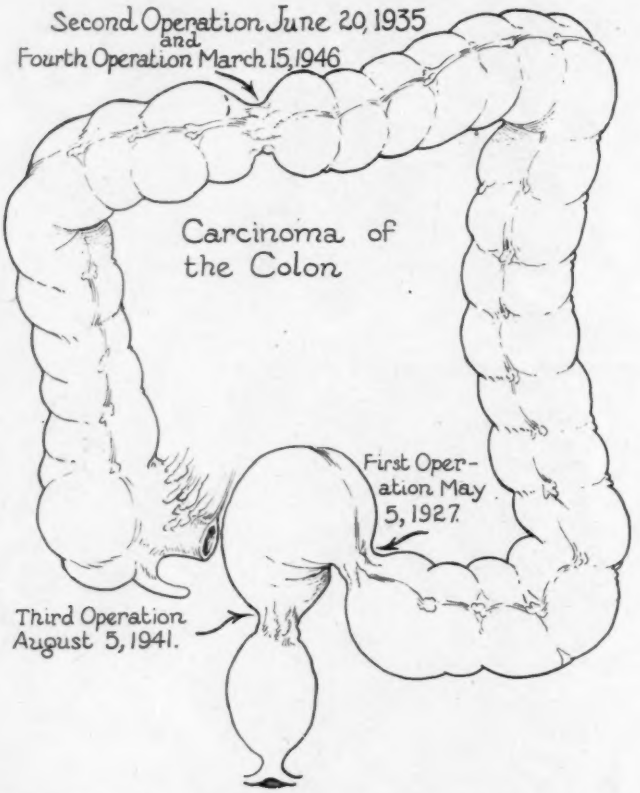
Second Operation June 20, 1935
and
Fourth Operation March 15, 1946
Carcinoma of the Colon
First Operation May 5, 1927
Third Operation August 5, 1941.

Fig. 4.—Schematic drawing showing approximate location of all four lesions. That removed at third operation was at a slightly higher level than indicated.

Convalescene was without incident and the patient was discharged from the hospital on Aug. 23, 1941. Proctoscopy on Sept. 24, 1941, revealed no narrowing at the level of the anastomosis.

Pathologic report (S.P. 41665, University Hospital) showed adenocarcinoma of sigmoid, grade II, with mucinous change.

Fourth Lesion.—During August, 1945, the patient became conscious of tenderness and an increasing firmness in the scar of the second operation in the right upper quadrant. He described a gurgling sensation, as of gas passing through a narrowed section of bowel beneath the scar. Barium enema confirmed this observation. Proctoscopy performed to 20 cm. was negative. A sulfasuxidine preparation, begun prior to admission to University Hospital on

March 13, 1946, was continued until operation two days later. A lens-shaped piece of scar and skin were included in the initial incisions, which were carried down to the peritoneal cavity wide of indurated tissue. Dense adhesions were severed in an attempt, with but somewhat limited success, to mobilize the transverse colon toward right and left flexures. It was possible to resect all involved tissue with two inches of gut to spare on each side of the lesion. End-to-end open anastomosis was effected with slight tension. Approximation of the parietes and skin was aided by contralateral incisions and Tiffany wire tension sutures. Slight separation of the skin margins at the middle of the wound with escape of watery material on the fifth postoperative day persisted for three weeks but did not interfere seriously with the convalescence, which had advanced sufficiently to permit discharge from the hospital on April 11, 1946.

Healing was complete two weeks later, by which time the patient had resumed his practice. Examination on Feb. 1, 1947, revealed the abdomen to be free from palpable recurrence. The patient's weight was 205 pounds, and he was very active for his age.

Pathologic report (S.P. 53931, University Hospital) revealed adenocarcinoma of transverse colon, with involvement of skin and parietes.

COMMENT

Of the four lesions removed, the first three were undoubtedly primary. The fourth may represent a recurrence of the second lesion. At least the scaffolding may have survived the ten intervening years. The pathologic findings are very similar in each of the four tumors.

The limitations for further interference in this case would appear to be either from lack of years or lack of available colon. Parenthetically, the patient has outlived two of his surgeons.

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BENIGN LYMPHOMA OF THE RECTUM

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AMONG the polypoid tumors of the rectum, clinically suspected of being adenoma or some other benign or even malignant tumor, some of them when examined microscopically prove to be composed of lymphoid tissue. This may occasion doubt as to whether one is dealing with a benign process, either hyperplastic or neoplastic, or a lymphosarcoma. Therefore, an analysis of the clinical and morphologic data obtained both from the literature and from the material of the Laboratory of Surgical Pathology of Columbia University may help one to know more about the nature of this growth.

Table I summarizes forty-nine cases of which those numbered 1 to 23 have been previously reported from other clinics, while the remainder were collected in this laboratory during a period of twenty-seven years, from 1920 to 1946.

Case 1 reported in 1890 by Ball[1] was clinically diagnosed as adenoma. The author presumed that the growth originated in the solitary lymphatic follicles of the rectum. He also mentioned that tumors like this unassociated with obvious lymphoid tissue disease in other parts of the body were previously not observed.

Case 2 reported in 1908-1909 by Greig[2] was termed "lymphoma" by this author, who agreed with Ball as to the origin and rarity of this growth at that time.

Cases 3 and 4, reported in 1925 by Lehmann,[3] were described as submucosal, nodular tumors with no tendency to bleed. He attributed the bleeding in one of his cases to the complicating hemorrhoids.

Case 5 reported in 1927 by Knoflach[4] was complicated by stomach cancer.

Case 6 was reported in 1931 by Konjetzny.[5]

Case 7 reported in 1931 by Siemens[6] was polypoid and considered benign by the author.

Cases 8 to 13 reported in 1932 by Dick[7] under the term of lymphadenoid rectal polyp were among seventy cases of polypoid rectal tumors of various natures. He concurred in the opinions of various investigators that this condition of growth is invariably considered to be hyperplasia of previous existing lymphoid tissue of the rectum and has never been proved to be a true tumor or granulaton tissue.

Case 14 reported in 1933 by Epstein[8] was described microscopically as a lobulated, submucosal nodule breaking the muscularis mucosae and penetrating into mucosa, and composed of large cells of a lymphocytic variety forming germinal centers. He described this growth as differing from the structure of a normal lymph node by the absence of a definite capsule, marginal sinuses, and medullary cords. He illustrated a number of cases reported, such as those of Gripp, Felizet, Branca, Broca, and Malgat. He also quoted Schwab's case of multiple polypi which was named diffuse lymphadenoma.

Cases 15 to 17 were reported in 1934 by Dukes.[9] Two of them were pedunculated tumors and the other was a submucosal induration. Histologically the three cases were identical with each other. He emphasized that the case with submucosal induration deserved to be mentioned because it resembled lymphosarcoma, which needs an entirely different treatment.

Case 18 reported in 1940 by Hayes and his associates[10] showed symptoms bearing no direct relation with the rectum except constipation. He agreed with others that the lesion he described is a benign lymphoid tumor or lymphomatosis.

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Cases 19 and 20 reported in 1942 by Gruenwald[11] were called by him, "Accumulations of lymph follicles in the digestive tract."

Cases 21 to 23 were reported in 1943 by Smith[12] under the name of primary lymphoid tumors of the rectum. The first of his cases was diagnosed lymphosarcoma but may well be considered as growth allied with the present group as illustrated in Table I.

From these tabulated data there are some general features which can be considered characteristic for this growth:

1. All these cases are free from associated generalized lymphoid disease.
2. The chief associated lesions are hemorrhoids and prolapse.
3. The chief symptoms are rectal bleeding, pain, and constipation.
4. The common pattern of the growth is a small, usually polypoid and commonly solitary nodule.
5. The nature of this growth is believed to be benign since in 33 out of the 49 cases in which follow-up has been carried out for different lengths of time there was no evidence of recurrence.

The general histopathologic study of our material and the review of some of the other authors' observations can be summarized as follows:

It is a noncapsulated yet well-circumscribed and often lobulated nodular growth which is composed exclusively of lymphoid tissue. This in turn is framed or supported by reticular tissue. The submucosal nodule often extends through the muscularis mucosae and involves the mucosa. Invasion of the underlying muscular coat has never been observed. The nodule is made of units of lymph follicles which contain all the cellular elements normally found in the lymphoid follicles of the intestine. Mitotic figures, regardless of their number, remain well within the limit of the germinal center and have not been found elsewhere. The number of mitoses varies among different follicles from the same case as well as from one case to another. A diffuse infiltration of different forms of wandering cells in varying intensity is many times encountered. The overlying mucosa suffers from compression of the underlying nodular growth, becomes therefore thin and straightened, and is thus exposed to mechanical injury.

So often and so closely does this growth resemble an adenomatous polyp of the rectum that it is difficult to differentiate one growth from the other. From the descriptions of the reported cases and the ones studied in this laboratory it would seem that the lymphoma, though often polypoid, is invariably broad based, feels firm and nodular, and is covered by comparatively normal looking mucosa. The adenomatous polyp is usually redder because of the congested capillaries near its surface. Since the lymphoma originates in the submucosa and only secondarily extends into the mucosa, it has a more solid base and is less often pedunculated than is the one with the adenomatous polyp in which the submucosa is unaffected.

Also, our observation inclines to separate this growth from lymphosarcoma by means of the histologic and cytologic study of the present material. In short, this growth is made of units of follicles with mitotic figures strictly limited to the germinal center, while lymphosarcomas are made of one type of cells such as small lymphoblasts in the case of the lymphocytic cell lymphosarcoma or of

TABLE I

CASES	SEX	AGE (YR.)	CHIEF SYMPTOMS*	DURATION	ASSOCIATED LESION†	NUMBER‡	SITE (DISTANCE ABOVE ANUS IN CM.) §	TREATMENT‖	FOLLOW-UP¶
1	M	6	0	?	P	M	Prolapse	Ex	0
2	F	30	a	?	P	S	Ant. wall	Ex	For some time
3	F	45	b	?	P	S	Post. wall, 5 cm.	Ex	0
4	M	35	a, b	2 yr.	0	M	7 cm.	Ex	0
5	F	59	b, d	?	Stomach cancer	M	?	Ex	0
6	F	40	b, c	Several mo.	0	M	Post. wall, 5 cm.	Ex	6 mo.
7	F	43	a, b	?	0	S	Post. wall, 5 cm.	Ex	0
8	M	44	b	?	0	S	Above sphincter	Ex	6 yr.
9	F	57	Tenesmus	Several mo.	0	S	5 cm.	Ex	2 yr.
10	F	56	b	Several mo.	0	S	?	Ex	1 yr.
11	M	26	a, b	?	0	M	?	Ex	6 mo.
12	F	39	(Foreign body feeling for several months and acute appendical symptoms)			M	Ampulla	Ex	3 mo.
13	F	50	a	Several mo.	Epithelioma of anus	M	?	Resection	0
14	?	46	a	15 yr.	H	S	Ant. wall, 5 cm.	Amputation	0
15	M	38	a	4 yr.	P	S	?	Ex	5 yr.
16	M	32	a	2 yr.	P	S	Ampulla	Ex	3 yr.
17	F	59	0	?	0	S	Lat. wall	Ex	0
18	F	31	c	?	Ant. fissure	M	8 cm.	Ex, x-ray	2 yr.
19	F	48	0	?	H, polyp of colon	S	?	Ex	0
20	F	60	0	?	0	S	?	Ex	0
21	F	42	0	?	H	S	?	X-ray	18 mo.
22	F	36	a, c	?	H	S	?	Ex	1 yr.
23	F	21	a	?	H, P	S	?	Ex	1 yr.

24	M	43	a, c	3 weeks	0	M	Ant. wall, 2 cm.	Ex	1½ yr.
25	F	34	a, b, c	1 week	H, P	S	Post. wall, 8 cm.	Ex	3 mo.
26	M	24	a, b	2 weeks	H, P, venereal dis.	M	Ampulla	Ex	3½ yr.
27	F	50	0	?	0	S	Ant. wall, 2 cm.	Ex	0
28	F	43	a, b, c, d	1 mo.	Ulcerative colitis	S	Lat. wall, 8 cm.	Ex	1 yr.
29	M	42	a, c	2 yr.	Gonorrhea	M	Left & rt. ant. wall	Ex	4 mo.
30	M	45	a, c	1 yr.	0	S	Ant. wall, 6 cm.	Amputation	28 mo.
31	F	71	c, d	9 yr.	0	S	5 cm.	Ex, x-ray	6 mo.
32	F	31	a	13 yr.	P	S	Post. levator	Ex	4 mo.
33	M	17	a	6-7 mo.	H, P	M	Ant. wall	Ex	3 yr.
34	M	45	a	?	H	S	Among hemorrhoids	Ex	11 mo.
35	M	40	a, c	5 yr.	H, P, fistula	M	Among hemorrhoids	Ex	4 mo.
36	F	27	b	3 days	0	S	Anal orifice	Ex, biopsy	0
37	M	22	d	29 hr.	0	M	Post. wall	Ex, biopsy	0
38	M	39	0	?	H	S	Ant. wall	Ex	0
39	M	56	c	?	H	S	Ant. wall	Ex	5 mo.
40	M	25	a, c	Many yr.	P	M	?	Ex	2 yr.
41	F	29	a	9 yr.	0	S	?	Ex biopsy	0
42	M	17	a	2 mo.	Fistula	S	Lat. wall, 4 cm.	Ex	3 yr.
43	F	49	a, b	3 mo.	P, ca. of rectum	S	Distal part	Resection	0
44	M	56	a	8 mo.	H	S	Ant. wall, 5 cm.	Ex	3 mo.
45	M	19	a, c	?	0	S	Lat. wall, 3 cm.	Ex	7½ yr.
46	F	7	a	2 weeks	P	S	Post. wall, 4 cm.	Ex	1 yr.
47	M	27	b, c	1 yr.	H, pruritus	M	Above anus	Ex	13 mo.
48	M	50	c	?	0	S	Ant. wall, a few mm.	Ex	8 yr.
49	M	44	0	?	Pruritus	S	Lat. wall, 2 cm.	Ex	6½ yr.

*a, Bleeding.
b, Pain.
c, Constipation.
d, Diarrhea.
0, None.

†P, Prolapse.
H, Hemorrhoid.
‡M, Multiple.
S, Single.

§The size of the tumor is small.
‖Ex, Excision.
¶There were no recurrences.

large cells in the case of reticulum cell lymphosarcoma. The difficult differentiation occurs in the tumors with giant follicles. If these growths are restricted to the mucosa and submucosa as occurred in a number of the cases here reported, the growth gives no clinical evidences of malignancy. If, on the

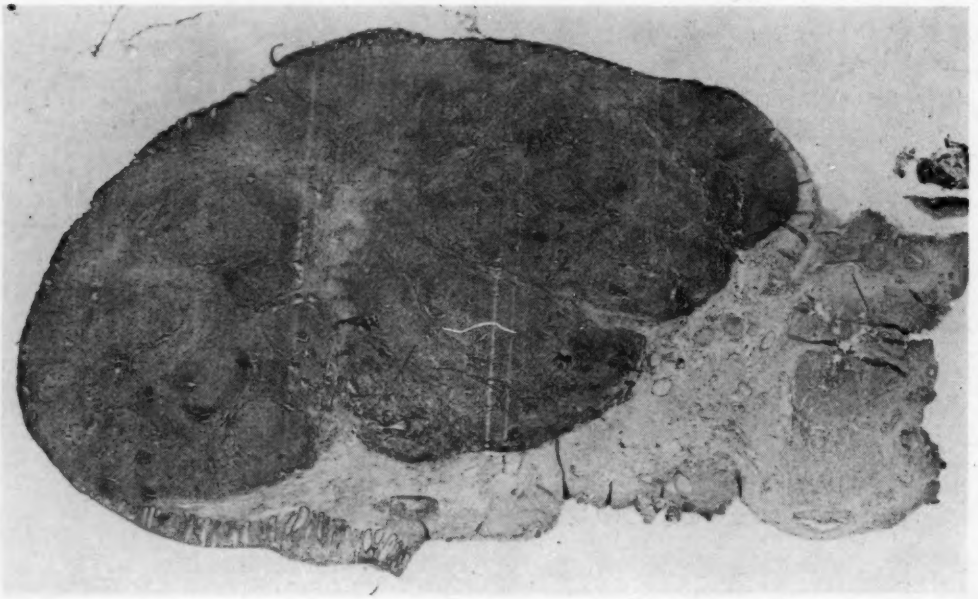

Fig. 1 (Case 33).—A wide-based polypoid growth of rectum showing a submucosal nodule of lymphoid tissue and the atrophied-covering mucosa.

Fig. 2 (Case 43).—A small lymphoid growth of rectum in comparison with the coexisting normal solitary lymph follicles in the wall.

other hand, there is infiltration into or through the muscular coat, the growth may be considered a lymphosarcoma.

It does not seem possible to decide from the data at hand whether this lesion should be considered a simple localized hyperplasia, as was originally suggested by Stout[13] in reporting Cases 46 and 49 of this series, or a true neoplasm. There does not even exist any proof that a lymphosarcoma can develop from one of these nodules. It is abundantly clear that these are benign growths. Since they are tumorlike it seems more reasonable to call them lymphoma, which is the

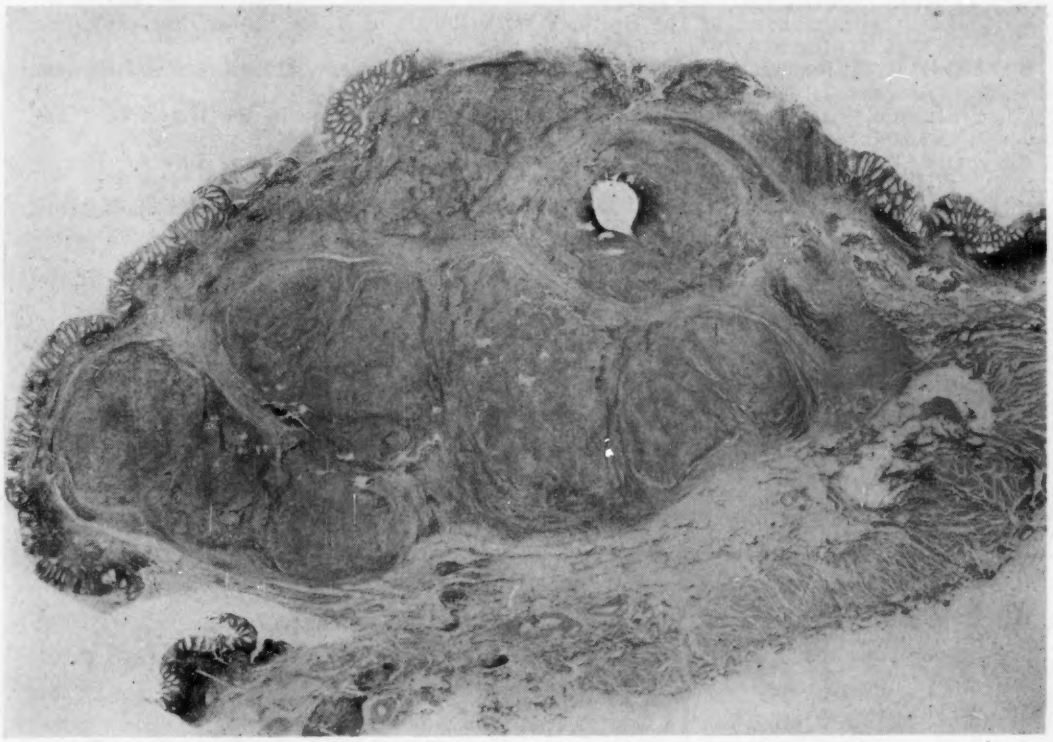

Fig. 3 (Case 48).—A very broad-based lymphoid growth of the rectum showing extension to mucosa through the muscularis mucosae and no invasion of the muscular coat of the rectum.

proper term to apply to a benign tumor of lymphoid tissue. Because this word "lymphoma" has been used by many clinicians as a loose term to cover all of the malignant lymphoid neoplasms it seems necessary to use the qualifying adjective "benign" with it in order to remove all doubt as to its nature.

SUMMARY

Forty-nine cases of benign lymphoma of the rectum are reported including twenty-six previously unreported ones. It is established that the growth involves the submucosa and mucosa, is often polypoid, resembles the adenomatous polyp, and is always benign.

The author expresses great appreciation to Dr. Arthur Purdy Stout for his kind supervision in the preparation and completion of this paper.

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GASTROSTOMY

A Statiscal Review of One Hundred Ninety-nine Cases

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GASTROSTOMY, as a measure for the control or betterment of the nutrition of ill patients, long has been a standard surgical procedure to be carried out upon selected cases. A recent editorial, however, by Meyer and Kozoll* indicated that the life expectancy of the majority of patients upon whom this procedure is carried out is little, or possibly adversely, affected by this operation. A review of the literature failed to reveal any recent significant statistical studies on a large group of patients. It was thus decided to review all the instances for which gastrostomy was performed at the University Hospital from 1934 to 1946 in an effort to evaluate further the procedure as palliative or therapeutic.

One hundred ninety-nine patients upon whom gastrostomy was performed form the basis of this study. Five of these are considered separately in the latter portion of this review and are not included in the discussion or statistical tables. It has been possible to obtain a recent follow-up report in all instances. Table I lists the primary diagnoses for which these operations were carried out. The vast majority were patients with neoplasms of the esophagus who comprise 109 (55 per cent) of the total. Other patients with neoplasms included 22 with carcinoma of the gastric cardia, 11 with carcinoma of the larynx, and 2 with bronchiogenic carcinoma. Thus, in all there were 144 patients (72 per cent) with malignant neoplasms. The patients with nonmalignant disease included 20 infants with congenital atresia of the esophagus, 10 patients with esophageal stricture as a result of caustic burns, 5 patients with cardiospasm, 1 patient with congenital stricture of the esophagus, and 14 patients with less common lesions (Table I).

Fig. 1 graphs the age incidence of these patients by decades. The majority of these patients were, of course, those with malignant neoplasm. Of the 25 infants and children in the first decade, 20 were operated upon because of congenital atresia of the esophagus.

There were 134 patients with inoperable neoplasms, so determined at the time of abdominal or thoracic exploration or because of evident widespread or distant metastases. Six additional patients were classified as inoperable. In this group were 4 patients with congenital atresia of the esophagus operated upon before it became apparent that primary anastomosis of the esophageal segments was feasible. One patient had widespread gastrointestinal tubercu-

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*Meyer, K. A., and Kozoll, D. D.: Editorial, Surg., Gynec. & Obst. 81: 221, 1945.

TABLE I. DIAGNOSES FOR WHICH GASTROSTOMY WAS CARRIED OUT

DIAGNOSIS	NUMBER
Esophageal carcinoma	109
Carcinoma of gastric cardia	22
Congenital esophageal atresia	20
Esophageal stricture (caustic)	10
Laryngeal carcinoma	11
Cardiospasm	5
Esophagobronchial fistula	4
Bronchiogenic carcinoma invading esophagus	2
Congenital esophageal stricture	1
Tuberculous esophageal ulcer	1
Postgastrectomy stomal stricture	1
Bulbar palsy, traumatic	1
Esophageal stricture of other etiology	5
Histoplasmosis	1
Thyroid carcinoma with esophageal invasion	1

losis and another histoplasmosis. In both instances, gastrostomy was performed in an attempt to control severe malnutrition. Thus, 140 (72 per cent) of the patients were considered inoperable; another 13 patients were estimated to have operable carcinomas. Only 41 patients (21 per cent) were in the nonmalignant group in which the primary lesion was either correctable or upon whom operation was unnecessary (Table II).

TABLE II. OPERABILITY OF PRIMARY LESION

LESION	NUMBER
Inoperable, neoplasm	134
Operable, neoplasm	13
Operable, nonneoplastic	38
Inoperable, nonneoplastic	6
No further operation required	3

The performance of gastrostomy is one of the earliest of surgical procedures. Because of some of the technical difficulties encountered in carrying out this simple operation, or because of the subsequent unsatisfactory functioning of the gastrostomy, many methods and variations have been advocated by various surgeons. At the present time the fashioning of a gastrostomy is varied by each surgeon to meet the needs of a particular situation and little importance is attached to the use of difficult or elaborate techniques. Since many gastrostomies are considered temporary expedients and not permanent fistulas the simpler procedures are felt to be most suitable. In many instances, because of the poor general condition of patients, the simplest procedure carried out under local anesthesia is obligatory. In Table III are listed the types of gastrostomy performed upon the patients under consideration in this study. Interpretation

TABLE III. TYPES OF GASTROSTOMY

TYPE	NUMBER
Stamm (Kader, Fontan)	96
Witzel	86
Janeway	8
Beck-Jianu	2
Transthoracic	1
Simple gastric cone	1

of the technique used was given wide latitude since the surgeon seldom utilized the exact technique described by the author to which the operation is ascribed.

In attempting to correlate the surgical complications and the difficulties entailed in the postoperative feeding regimes, a detailed examination of each complication in relation to the surgical technique used was made. The percentage of complications encountered in each instance was, with one exception, without significant difference; a significantly greater number of patients experienced stomal malfunction after the Stamm type of gastrostomy.

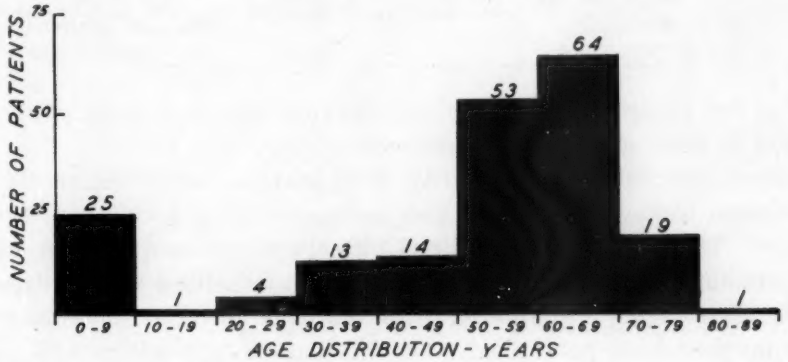

Fig. 1.

Again, the type of anesthetic agent has been implicated in the production of increased morbidity and mortality rates. In each case the anesthetic agent in this series of patients was chosen to meet the qualifications of the patient and the requirements of the surgeon. In this group of 194 patients, gastrostomy was carried out 109 times with local procaine infiltration anesthesia, 79 times under general inhalation anesthesia and 6 times with spinal anesthesia. No clear-cut correlation with postoperative complications or cause of death, definitely attributable to the incorrect choice of anesthetic agent, was noted.

There were 82 patients (42 per cent) of the 194 upon whom gastrostomy was performed in whom no postoperative complications occurred. In the remaining 112 patients there occurred a total of 147 complications. These complications are listed, in the order of their frequency of occurrence, in Table IV.

It will be noted that pneumonitis was the most frequent complication. There appeared to be close correlation between the severity of malnutrition and the incidence of pneumonitis in these patients, in that 41 of the 47 patients gave evidence of extreme weight loss, anemia, and hypoproteinemia. Twelve of these 47 patients had congenital esophageal atresia with tracheoesophageal fistulas. This primary lesion may well have contributed importantly to the incidence of pneumonitis.

The discrepancy between the incidence of phlebothrombosis or thrombophlebitis and pulmonary embolism can be explained only by the failure of the attending physician to look for or find evidence of venous thrombosis in the lower extremities. Three of these five patients were operated upon before this entity and its relationship to pulmonary embolism was fully recognized. In one of the other two patients the peripheral venous thrombosis was either not

TABLE IV. POSTOPERATIVE COMPLICATIONS

COMPLICATION	NUMBER
Pneumonitis	47
Wound infection	29
Unsatisfactory stoma (leakage outside)	23
Peritonitis	6
Mediastinitis	5
Pulmonary embolism	5
Wound dehiscence	4
Urinary tract infection	2
Thrombophlebitis or phlebothrombosis	1
Others (see text)	25
82 gastrostomies	No complications
112 gastrostomies	147 complications

present or not recognized. Two of the patients who died from pulmonary embolism did so after subsequent thoracotomy.

A most distressing postoperative complication, occurring in 23 patients, was persistent leakage of formula and gastric secretion from about the gastrostomy tube. These patients complained bitterly of constant leakage excoriation of the parastomal skin, and a constantly wet, ill-smelling wound dressing. In 17 of the 23 patients encountered with this complication, the Stamm type of gastrostomy had been performed. Of the remaining 6 patients, 4 had a gastrostomy of the Witzel type and on 2 patients a Janeway procedure had been carried out. Thus, it appears that, in our hands, a high incidence of unsatisfactory stomal function is to be expected from the utilization of the Stamm technique of gastrostomy.

Despite this large number of patients with malfunctioning gastrostomy stomas serious wound infections occurred in only 4 of these patients.

Twenty-five patients developed postoperative complications often seemingly unrelated to the performance of gastrostomy. In many instances these complications were more directly related to the age of the patient (cerebrovascular accident) or to the sequelae of the underlying disease (chylothorax, empyema, esophagopleural fistulas, lung abscess). In a few patients a totally unrelated complication occurred such as acute gangrenous appendicitis, otitis media, and strangulating femoral hernia.

It is evident that an over-all view of the survival time of the entire group of 194 patients (Table V) is of no value in deciding the degree of palliation

TABLE V. SURVIVAL

TIME INTERVAL OF GASTROSTOMY AND LAST FOLLOW-UP OR DEATH	ALIVE	DEAD	CUMULATIVE DEAD (PER CENT)
Less than 1 mo.		83	43
1 to 3 mo.		39	63
3 to 6 mo.		22	74
6 to 12 mo.	1	21	84
1 to 2 yr.	3	6	87
2 to 3 yr.	4	3	89
3 to 4 yr.	4	2	90
4 to 5 yr.	2		90
Over 5 yr.	4		90
Total	18	176	90

TABLE VI. SURVIVAL BY DIAGNOSIS

DIAGNOSIS	TOTAL PATIENTS	LESS THAN 1 MO.	PATIENTS LIVING AFTER INDICATED TIME INTERVAL FOLLOWING GASTROSTOMY							LIVING OVER 5 YR.	TOTAL DEAD	PER CENT MORTALITY
			1-3 MO.	3-6 MO.	6-12 MO.	1-2 YR.	2-3 YR.	3-4 YR.	4-5 YR.			
Esophageal carcinoma	109	63	34	18	7	2	1	1	1	1	108	99.1
Esophageal stricture, caustic	10	10	9	9	8	8	8	7	7	7	3	30.0
Cardiospasm	5	4	3	2	2	2	2	2	2	2	3	60.0
Congenital atresia of esophagus	20	5	5	5	4	4	4	4	4	4	16	80.0
Bronchiogenic carcinoma involving esophagus	2	1	1	0	0	0	0	0	0	0	2	100.0
Carcinoma of gastric cardia	22	14	8	6	1	1	0	0	0	0	22	100.0
Esophago-broncho fistula	4	4	3	2	2	2	2	1	1	1	3	75.0
Laryngeal carcinoma	11	5	4	3	0	0	0	0	0	0	11	100.0
Congenital esophageal stricture	1	1	1	1	1	1	1	1	1	1	0	00
Other rare feeding problems*	10	5	4	3	2	2	2	2	2	2	8	80.0

*See Table I.

offered by gastrostomy where palliation alone is desirable, nor is it evident to what degree nutrition is facilitated or improved where this feature is of utmost importance. An examination of survival time in relation to diagnosis (Table VI) is more illuminating but cumbersome for such a study.

Therefore, in an effort to determine further whether or not true palliation was achieved by the performance of gastrostomy in patients with hopelessly unresectable neoplasms, these patients were considered in a single group in Table VII, *A* and their survival time was determined to five years. Eighty-three per cent of these patients were dead within six months, the majority dying within less than one month. It then appears that the 18 patients who have survived longer than this period were possibly greatly aided by this operation.

It will be noted that 3 of these 18 patients lived longer than one year. A close scrutiny of these indicates that they were still capable of ingesting food orally and that the gastrostomy was done primarily for future need. In 2 of these patients the gastrostomy tube was removed shortly after it had been placed and the third patient received gastrostomy feedings only the last two or three months of his existence. One patient in this group had excellent palliation from x-ray therapy given to the esophageal lesion.

The remaining 15 patients living longer than six months showed a somewhat lesser degree of malnutrition as well as neoplastic lesions which progressed more slowly. Four of these patients had carcinomas of the larynx, 6 had neoplasms of the gastric cardia, and 5 had carcinomas of the esophagus. We have concluded from observations on this group of patients that life expectancy, from the time the diagnosis was verified, was directly related to the degree of starva-

TABLE VII. SURVIVAL BY PREOPERATIVE INDICATION

PREOPERATIVE INDICATION		TOTAL PATIENTS	0-1 MO.	1-3 MO.	3-6 MO.	6-12 MO.	1-2 YR.	2-3 YR.	3-4 YR.	4-5 YR.	OVER 5 YR.	TOTAL DEAD	TOTAL LIVING
A. Palliation, hopeless carcinoma		109	50	29	12	15	2	1	0	0	0	109	0
B. Control nutrition operable carcinoma		18	4	4	3	2	4					17	1
C. Palliation; hopeless not neoplasm		6	6									6	0
D. Therapeutic	(1)	33	12	2	3	2			2			21	12
Total patients, 41	(2)	8	1	1		1						3	5
E. Neoplasm, hopeless; radium application		20	9	4	5	2						20	0
Total		194										176	18

tion present and that nutrition was not aided materially by the performance of a gastrostomy. Therefore, when a hopelessly irremovable neoplasm of the larynx, esophagus, or gastric cardia is present, the performance of a gastrostomy did not appear, in the patients studied, as an important means of improving nutrition and thus prolonging life.

Gastrostomy was performed on 18 patients (Table VII, *B*), with lesions of the esophagus and gastric cardia as a preliminary procedure to surgical resection of the primary lesion. In 5 of these patients resection was later abandoned because of the wide extent of the lesion. All 5 of these patients died within six months and their course apparently was not modified by the gastrostomy.

The remaining 13 patients, with one exception, died within two years of the time of resection of the neoplasms. Four patients in this group should be considered operative mortalities since they failed to survive longer than several days postoperatively. The remaining patients died from progression or recurrence of the original neoplasms.

One patient of this group survived to date and is now living, seven years after esophagectomy, with a cervical esophagostomy. The entire nutrition is well maintained through the gastrostomy.

Six patients (Table VII, *C*) were considered to have incurable, nonmalignant disease. Four of these were patients with congenital esophageal atresia. At the time these patients were seen, esophageal anastomosis for restoration of the esophageal continuity was not considered feasible. One patient with widespread miliary tuberculosis and a second patient with histoplasmosis were operated upon in an attempt to improve nutrition. All of these patients died within less than one month following operation and none were benefited by the operation.

Forty-one patients (Table VII, *D*) had non-neoplastic operable lesions for which gastrostomy was performed. These patients were further divided into two subgroups; the first includes those patients for whom the gastrostomy was done in order to combat starvation and in whom treatment of the causative lesion must of necessity depend upon nutritional control. The second group is comprised of patients for whom the gastrostomy was done primarily to facilitate the treatment of the causative esophageal lesion. In this latter group nutrition was, in general, good—the gastrostomy functioned not as a palliative measure and minimally, if at all, as an adjunct to nutrition.

In the first subgroup of Table VII, *D* (1) are a total of 33 patients, 12 of whom are living. The lesions for which the gastrostomy was performed in these 12 living individuals were as follows: cardiospasm, 2 patients; bronchoesophageal fistula, 1 patient; congenital atresia of the esophagus, 4 patients; caustic stricture of esophagus, 3 patients; traumatic bulbar palsy, 1 patient; operative stricture of hypopharynx, 1 patient.

At the time of this writing, the gastrostomy is still functioning in only 2 of these patients; it has been present for five years in 1. Retrograde esophageal dilatations are still being carried out through one gastrostomy stoma, and the second patient has refused surgical correction of the bronchoesophageal fistula and thus depends greatly upon the gastrostomy intake.

In all 10 of the patients in whom the gastrostomy was closed, it was possible to supplement, early, the gastrostomy feeding with an increasing oral intake. In some instances the gastrostomy was maintained long after its utilization for feeding was required in order to facilitate treatment of esophageal obstruction.

In this small group of 12 patients, now living, gastrostomy was performed primarily for feeding but soon became only a supplementary means of increasing the oral intake. As such, it has probably contributed materially in the maintenance of good nutrition in these individuals.

Twenty-one patients in this first subgroup died. Twelve of these were infants with tracheoesophagal fistulas, 10 of whom died of aspiration pneumonitis, 1 of hemorrhage, and 1 of tuberculous meningitis. Of the remaining patients, 3 were operative deaths, the deaths resulting from operations carried out subsequent to gastrostomy in order to correct the primary diseases. One patient with a bronchoesophageal fistula died of a suppurative pneumonitis, 1 patient committed suicide, and 1 died of a drug reaction. One severely psychotic patient presumably died of inanition, and in 1 patient the cause of death was unknown. One patient with a postoperative esophagopleurocutaneous fistula failed to improve following gastrostomy, because of regurgitation of the gastrostomy feedings through the fistula, and also failed to improve after jejunostomy.

In the group of patients now dead, 7 survived longer than three months from the time at which gastrostomy was performed. These patients undoubtedly derived some benefit from gastrostomy. In 2 patients with bronchoesophageal communications, benefit may well have been derived simply from defunction of the esophagus as a food passage, thus delaying the onset of aspiration pneumoni-

tis. In the remainder, satisfactory supplementation of a diminished oral intake must be ascribed to the gastrostomy.

Eight patients are considered in the second subgroup of Table VII, *D* (2). In each instance gastrostomy was performed in order to facilitate esophageal dilatation. Three patients in this class died. One of these died of a cerebral thrombosis, another from a mediastinitis following instrumental esophageal rupture, and a third from an unknown cause. All patients now living have the gastrostomies closed.

In this group of 41 patients with non-neoplastic, curable lesions, gastrostomy finds its most important use as a means of aiding the surgical treatment of the obstructing lesion. Feeding, as a means of prolongation of life, has been aided only by supplementation of oral intake.

Between 1934, the date from which this study was begun, until 1939, 20 patients with carcinoma of the esophagus were treated by gastrostomy and retrograde implantation of radium (Table VII, *E*). Eight of the patients so treated failed to tolerate this procedure and died within fifteen days of operation. The great majority of the patients who lived longer than one month was able to ingest a soft or general diet for a variable period of time after operation due to the dilatations attendant upon the treatment. In two instances the gastrostomy tube was removed. The life expectancy after this form of treatment was less than one year in all instances and depended primarily upon the rate of neoplastic extension and the occurrence of aspiration pneumonia. In no instance did the life expectancy or improvement in nutrition appear to be aided materially by the performance of gastrostomy.

Thus, of 194 patients upon whom gastrostomy has been performed over a period extending from 1934 to 1946, 18 patients (9 per cent) are still living at the time of this communication. Seventeen of these surviving patients are those with non-neoplastic, presumably curable disease. In this group alone does gastrostomy appear as a most useful and worth-while surgical operation.

Five patients, not included in the foregoing discussion, were somewhat unique in that each was subjected to gastrostomy upon two occasions. Two of these patients had far-advanced carcinomas of the esophagus. In one, radium implantation was done, a short period of symptomatic improvement occurred, and the gastrostomy was permitted to close. Early recurrence of symptoms required re-gastrostomy and the patient's subsequent course was no different than that of the other patients discussed in the preceding portion of this study. In the second patient, gastrostomy was performed as a preliminary to esophagectomy. Esophagectomy was later abandoned and the gastrostomy was allowed to close for lack of use. Eventual total obstruction necessitated reopening of the gastrostomy. This individual survived less than one month postoperatively.

Three patients with esophageal strictures also required gastrostomy on two occasions. In each instance, following satisfactory response to dilatation, the gastrostomy was permitted to close. Subsequent recurrence of obstruction necessitated reoperation. Two of these patients were alive and well more than five years following the original gastrostomies. One patient died of an aspiration pneumonitis.

These patients offer no different problems or conclusions than those referred to in our previous discussion.

DISCUSSION

The value of the palliative gastrostomy in patients with inoperable malignant neoplasms or other hopelessly incurable lesions is certainly brought to question by the data herein presented. It seems certain that no significant extension of life has been gained for these patients. The question then resolves itself into one of the degree of physical or mental comfort afforded these patients by this operation.

The difficulties encountered in the utilization of the artificial stoma for feeding are noted in Table VIII. In 57 per cent of the patients no adverse feeding complications occurred. In these, both physical and mental comfort may have been afforded by the operation. Thirty per cent of the patients, however, experienced one or more complications associated with feeding through the gastric stoma. The majority of these were associated with actual discomfort. Those patients listed as "uncooperative" apparently experienced minimal palliation as they repeatedly and willfully removed the gastrostomy tubes against the physicians' orders.

TABLE VIII. FEEDING COMPLICATIONS

COMPLICATIONS	NUMBER OF PATIENTS
No complications encountered	110
No feeding attempted	26
65 complications occurred in	58
Leakage, outside	23
Diarrhea	17
Vomiting	10
Leakage, intraperitoneal	6
Uncooperative patient	4
Regurgitation into leaking esophageal anastomosis	4
Abdominal pain (severe)	1

Thus, the value of a contemplated "palliative" gastrostomy must be judged for each individual patient and the basis for this judgment must lie on an estimate of the patient's ability to cope with the problems of this manner of feeding, and upon his physical and mental reaction to the degree of starvation already present.

Gastrostomy is obligatory for those patients from whom the entire esophagus has been removed. It apparently functions satisfactorily either as a means of direct feeding or as a site of junction for an antethoracic esophagus. Today total extirpation of the esophagus for neoplasm by the method of Torek has been abandoned in this hospital. Under such circumstances the gastrostomy in patients with esophageal neoplasms falls again entirely within the realm of palliation, and as such seems of little aid.

However, in those patients for whom esophagectomy has been performed the gastrostomy has been of obvious value. Its use in such patients is necessary and therefore justifiable. It should be noted here that this group of patients

offers the best test example of the adequacy of the present-day methods of tube feeding. It has been our experience that gastrostomy-fed patients seldom attain the nutritional improvement and sense of well-being that is usually expected from a carefully selected, suitably calculated diet.

While the outstanding place for the use of a gastrostomy lies in those individuals upon whom total esophageal resection has been done, this is the least gratifying group of patients. The life expectancy is frequently not great and many of these elderly individuals find much difficulty in mastering the simple technique of tube feeding. Fortunately, the frequency of this indication for gastrostomy is small.

For the more hopeful non-neoplastic lesions, gastrostomy would seem ideal. This is our experience where the gastrostomy is necessary primarily to facilitate surgical correction in the esophagus or hypopharynx. In the group of patients in this study the gastrostomy has been of much aid in facilitating subsequent dilatations of the esophagus. It has been somewhat less satisfactory in this same group of individuals where its need has been dictated by starvation. Here again we have been impressed by our inability to gain the desired nutritional control over patients when the customarily diversified oral diet is replaced by an unvaried scientifically calculated one. However, when it has been possible to augment the gastrostomy formula early by an oral diet, such gastrostomy-fed patients have shown good nutritional response.

The fact that a large number of individuals in this group are now dead does not necessarily reflect discredit upon the procedure of gastrostomy. The causes of death in these patients seem directly attributable to their primary diseases or to complications resulting from the treatment thereof. In no instance was the patient's course adversely affected by the performance of the gastrostomy. However, the degree of positive nutritional support offered by the gastrostomy, although difficult to estimate, is certainly less than was desired or hoped for. It is even possible that the high mortality associated with the treatment of the primary diseases in this group of patients may reflect to some degree the inadequacy of the nutritional regimen afforded by the gastrostomy feedings.

In evaluation of the operation of gastrostomy it must be remembered that frequently, as in other palliative operations, brilliant results are seldom expected or observed. These operations are often carried out in the desperation of the surgeon and the patient's family. Such operations are probably justified, since they frequently add to the comfort of the patient and help to maintain the aggressive attitude of the surgeon in attacks upon lesions that are far advanced and frequently hopeless.

CONCLUSIONS

1. A palliative gastrostomy in patients with inoperable malignant neoplasms or other hopelessly incurable lesions produces no significant extension of life and no demonstrable nutritional improvement.

Since neither life expectancy nor outstanding nutritional improvement is to be gained by "palliative" gastrostomy, the use of this procedure for hope-

iessly incurable lesions must depend upon the surgeon's judgment of each individual patient as to the degree of physical and mental satisfaction which will be afforded by such an operation.

2. Gastrostomy in patients with non-neoplastic curable lesions of the hypopharynx, esophagus, and esophagogastric junction serves admirably as a means of furthering the local treatment of these areas. When the nutritional need is great in these patients, the nutritional response is maximum only when the gastrostomy feeding is supplemented by an oral diet.

3. A satisfactory state of nutrition is best maintained in esophagectomized patients when they are able to ingest a diversified diet through either an artifical or a surgically reconstructed esophagus.

AN IMPROVED DRAIN FOR PERITONEAL LAVAGE

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INTEREST has again been revived in the use of peritoneal lavage for the relief of certain types of azotemia.

In the early work with this method[1, 2] glass cannulas with multiple perforations were utilized; however, considerable difficulty was encountered because of the plugging of the perforations by omentum and there was evidence of irritation of the intestinal wall. Recent authors[3] successfully used a sump drain as described by Babcock,[4] for removal of irrigation fluid. However, the disadvantages of this type of drain are:

(1) Rigidity of the tube with resulting pressure to intestines
(2) Constant suction of contaminated air into the peritoneal cavity
(3) Occasional plugging of the small openings
(4) Leakage of lavage fluid into the dressing, which is a potential source of infection and which makes exact determination of nitrogen output difficult
(5) Difficulties of proper aseptic fixation of the tube on the abdominal wall.

To obviate these drawbacks in our setup for peritoneal lavage a new drain was devised.* Figs. 1 and 2 are photographic representations of the assembled and disassembled drains, respectively. The average drain consists of an upper rigid tube 3⅛ inches long and 5/16 inches inside diameter (*A*), with an interchangeable lower, spiral, flexible, stainless steel coil extension of 3 or 4 inches in length (*B*).

A straight inner tube (*C*), 3½ inches long, extends from beyond the outlet of the right angle tube (*D*), down into the upper half inch of the flexible tube. This inner tube is fitted with a rubber tube connection for suction aspiration.

There is an air space between the inner and the outer tube which connects with a right angle air inlet tube (*D*). This tube is connected to a rubber tubing to which is attached a suitable air filter.

We used a glass funnel covered with several layers of sterile gauze. It is obvious that when suction is applied to the outer tube, and there is no fluid available, filtered air will enter into the drain.

Since no negative pressure of significance can develop in the drain, omentum will not be drawn into the interstices of the spring coil.

At the outer portion of the steel tube there is an adjustable tie plate (*E*) for fixation by means of adhesive plaster.

Using a Stedman pump on a five gallon bottle attached to the drainage tube, a maximum flow of 240 c.c. per minute of fluid can be obtained, while during peritoneal lavage a maximum outflow of only 30 to 60 c.c. of fluid is required.

To test the possibility of development of a negative pressure, measurements taken on the bottom of the rigid tubing by attaching it directly to a manometer

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*Manufactured by Speedo Manufacturing Company, New York, N. Y.; patent pending.

at maximum rate of suction showed a negative pressure of less than minus 2 mm. of water.

We have used the drainage tube described here for peritoneal lavage in dogs and have found it satisfactory without the drawbacks previously mentioned. It will be used for clinical purposes.

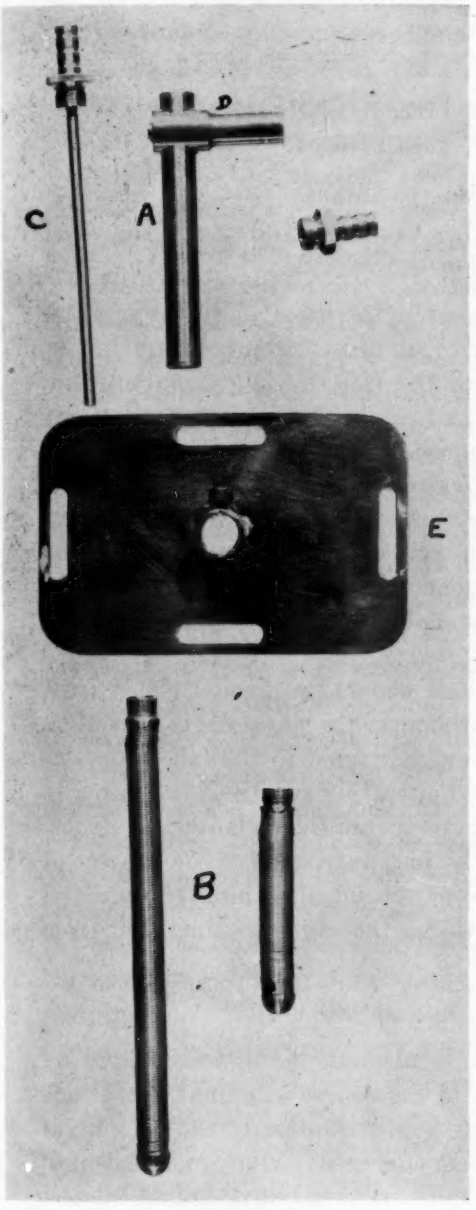

Fig. 1.

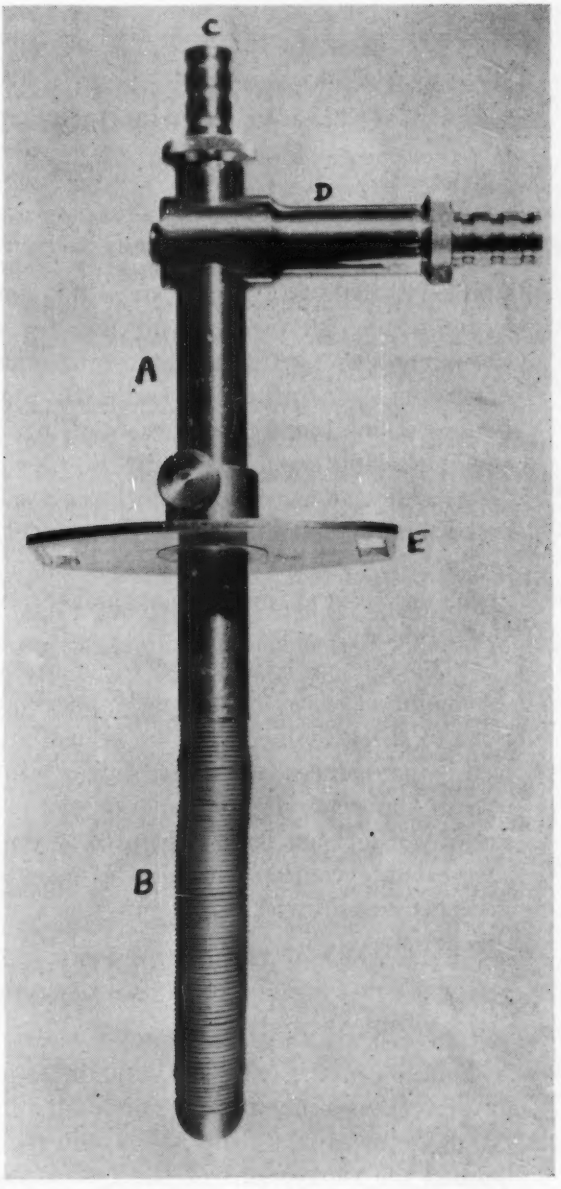

Fig. 2.

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PROGRESS IN SURGERY OF THE AUTONOMIC NERVOUS SYSTEM, 1943-1946

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IN THE four-year period since the last review of progress in surgery of the autonomic nervous system[1] many papers of interest have been published. These concern particularly wartime studies of the role of the sympathetic innervation in painful post-traumatic states and the value of sympathectomy for increasing blood flow in cases of injury to major arteries; also the continued and increasing experience with the surgical treatment of essential hypertension. Even while the war was still in progress laboratory investigators in this country and England continued to turn out much profitable work. This was brought up to date in the recently published Spanish monograph of Pi-Suñer[2] and in an article on visceral functions of the nervous system by Hare in the *Annual Review of Physiology*.[3]

This review is intended for neurologic and general surgeons. It is from this point of view that I have undertaken to summarize physiologic investigations of direct clinical bearing which have been conducted in the laboratory, as well as procedures established in the clinic and operating theatre in attempts to correct abnormal visceral function or to relieve pain connected therewith. Nothing of the sort has been attempted in the works just mentioned. The subject of surgical intervention for relief of essential hypertension was, however, well reviewed by Smithwick[4] from just this angle and has therefore been omitted from this article.

ANATOMY

Investigations carried out by means of careful anatomic dissection and by stimulation of the efferent sympathetic fibers in the course of spinal operations have given us a much clearer understanding of the distribution of the peripheral sympathetic impulses and how to interrupt them effectively. Pick and Sheehan[5] studied the connections of the sympathetic chains in twenty-five human dissections. The thoracolumbar outflow in man was found to leave the spinal cord between its first thoracic and second lumbar segments, with occasional apparent contributions from the eighth cervical root. While the uppermost origin of the major splanchnic trunk was usually from the sixth, occasional variations in this level were found as high as the fourth and as low as the eighth thoracic roots.

In view of the fact that many textbooks illustrate the white ramus as leaving the spinal nerve proximal to the gray, it is of interest to note that in this careful study exactly the opposite arrangement was found, at least in the thoracic region. Double, occasionally triple, sympathetic chains were found at times, but as these never extended over a greater extent than the space between two neighboring ganglia, this is of no surgical concern. The same is true of transverse connections between the two sympathetic trunks, which were never encountered above the fifth lumbar level. The possibility of any bilateral innervation of the limbs via such transverse connections can be almost certainly excluded. Variations in the position and number of the paravertebral ganglia are of interest, especially in the lumbar region, where it was rarely possible to define the separate ganglia with any certainty.

Determination of the spinal origin of the pupillary dilator and vasoconstrictor fibers was carried out in the human being for the first time by Ray, Hinsey, and Geohegan.[6] Pupillary dilation was obtained by electrical stimulation of anterior roots and was found to travel over one or more roots between the eighth cervical and fourth thoracic, most commonly in the first and second thoracic. In sixteen patients in whom the level of preganglionic innervation to the hand was investigated it was found that the usual source of the sympathetic outflow arose from the second to ninth thoracic, although in one case stimulation of the first thoracic root, and in two others of the tenth thoracic, gave rise to a definite change in the electrical resistance of the skin. It is also of interest that if a single one of these roots was left intact the degree of sympathectomy was far from complete and resulted in very partial clinical improvement.

From the more fundamental viewpoint, Hillarp's[7] microscopic studies of the peripheral endings of the autonomic neurones are of considerable interest. Previous microanatomists, Stohr and Boeke (referred to by Hillarp), had claimed that the connections at the ganglionic synapses and between the terminal nerve endings and the effector cells were formed by a nervous syncitium. This Swedish microscopist by more refined staining of the terminal fibers found that the construction of the ganglionic pericellular apparatus is incompatible with the existence of a terminal reticulum. The peripheral nerve network consists of "a terminal Schwann plasmodium, within which terminal axon ramifications are running. . . . Within the ground plexus each axon has a certain extension, and innervates in its course a certain number of cells. . . the neuro-effector unit. . . . A neuro-effector unit is not innervated by one neurone alone, however, but several neurones converge towards it. . . . By the overlap thus present . . . the response of the autonomic effector system on indirect stimulation may be modified both by temporal and by spatial summation effects." The objections raised by Stohr and Boeke against the neurone doctrine were evidently based on unreliable neurohistologic methods.

The importance of sensory fibers in the visceral nerves was emphasized by Langworthy,[8] who pointed out that many terminate in smooth muscle and glandular structures. Their cells of origin are in the sensory ganglia of the spinal and cranial nerves. No sensory cells have been demonstrated in the

autonomic ganglia, so no reflex arc can be mediated through the peripheral autonomic structures. Smooth muscle reacts to stretch stimuli, and the tone of hollow viscera (for example, bowel and bladder) is maintained by afferent stimuli from the muscle itself. While proprioceptive impulses from the viscera rarely reach the level of consciousness, the splanchnic and other visceral nerve trunks contain large numbers of sensory fibers whose role in the appreciation of pain in many chronic diseases is of particular importance to the surgeon. The role of sympathectomy in these conditions will be discussed.

PHYSIOLOGY

To the modern medical man brought up on the concept that the parasympathetic and sympathetic divisions of the autonomic nervous system are of exactly equal importance in the nicely balanced control of homeostasis, Langworthy's[8] discussion of the general principles of autonomic innervation will be most provocative reading. Basing his arguments against the universally accepted theory that the craniosacral and lumbar divisions are functionally antagonistic, Langworthy pointed out that in such dually innervated organs as the iris and the bladder the parasympathetic is of paramount importance in the innervation of smooth muscle, while the sympathetic exerts its influence solely through the medium of the circulation.

In the case of the urinary bladder the sympathetic fibers have been referred to as the nerves of bladder filling and the sacral parasympathetics as the nerves controlling bladder emptying. This is obviously an oversimplification, as resection of the superior hypogastric plexus (presacral neurectomy) has no effect on micturition, while section of the second to fourth sacral roots or the inferior hypogastric plexus produces complete paralysis. In so far as the bladder is concerned there is no doubt that many of the phenomena ascribed to sympathetic nerve-muscle action can be explained by changes in the caliber of the blood vessels or by contraction of the smooth muscle in their walls.

In the case of the iris it must be realized that the constricted pupil seen in the Claude-Bernard-Horner syndrome is still capable of undergoing reflex widening as well as narrowing through the unopposed action of the oculomotor nerve. The role of the sympathetic in pupillary dilatation is ascribed by Langworthy[8] to constriction of the blood vessels and reduction of the spongy vascular tissue of the iris, while he believes that all adjustments in the actual muscle fibers are controlled solely by the parasympathetic outflow over the third nerve. Ophthalmologists agree that engorgement of the spongy iris tissue may make the pupil smaller; such is the condition seen in iritis; but the impressively thick wall of the iris vessels is made up uniquely of hyaline material, and not of smooth muscle fibers as Langworthy assumed.

The work and writings of the late Walter B. Cannon have made such a clear-cut case for the antagonistic action of the two divisions of the autonomic nervous system on smooth muscle in general that any exception of this sort in such an important structure as the iris deserves most careful scrutiny. In going back through the literature the classical investigations of Langley and

Anderson[9] published in 1892 seem to refute Langworthy's criticism in an unequivocal fashion. These British physiologists made radial cuts through the iris to eliminate the action of the circular sphincter muscle. In dogs and cats there was definite retraction of this free wedge-shaped strip of iris each time the cervical sympathetic trunk was stimulated. They furthermore proved that this movement could be explained only by the presence of an active dilator muscle, and not through any action of its radially arranged blood vessels. Not only does the radial muscle contract before its blood vessels constrict, but it contracts so forcibly that they become angulated and tortuous, indicating a purely passive shortening on their part. Langley and Anderson also cited earlier experiments by Budge and François-Franck showing that pupillary dilatation on sympathetic stimulation continued even after the animal was bled to death. In addition it is important to recall Bean and Bohr's[10] observation that even in vitro the smooth muscle of the radial muscle contracts directly under the influence of adrenaline, proving that there must be a direct sympathetically mediated pupillodilator response.* The work of Cannon showed that the craniosacral outflow is of prime importance in the control of adjustments of single organs, while the sympathetic acts on the body as a whole under emergencies such as fear, exertion, and exposure. Langworthy's conclusion that there is no real antagonism between the two systems appears to be true in the case of the bladder, but he does not produce convincing proof against the dual control of the iris, nor any evidence whatever against the dual control of other important organs such as the heart.

Another fundamental principle discussed by Langworthy is the comparative differentiation of the various types of motor nerves. The skeletal motor fibers are of the highest differentiation and are most dependent on control through the central nervous system. The sympathetic fibers show the least differentiation, are least dependent on control through the central nervous system, and are least responsive to voluntary control. The parasympathetic fibers hold an intermediate position. The sympathetic fibers reach all portions of the body in their role of vasoconstrictors, whereas the parasympathetic have both a more limited distribution and a more specific action. While total removal of the sympathetic ganglionated chains can be tolerated with only limited inconvenience by the cat, dog, and man, deprivation of the craniosacral outflow would lead to far more serious consequences.

Our understanding of the central control of homeostasis has been forwarded by the experimental studies of Beaton and his co-workers.[11-13] Three distinct mechanisms serve to maintain a constant body temperature, namely, heat loss, heat conservation, and heat production. Local heating of the preoptic hypothalamic nuclei with the high frequency current causes sweating, vasodilatation, and increase in respiratory rate. Conversely, an inability to eliminate excess heat and a consequent rise in body temperature follows bilateral lesions placed in the anterior hypothalamus. Sweating is inhibited, the cutaneous blood vessels

*I am indebted for these pertinent earlier references to Dr. Francis H. Adler, Professor of Ophthalmology, University of Pennsylvania; Dr. David G. Cogan, Director of the Howe Laboratory of Ophthalmology, Harvard Medical School; and Dr. Arturo Rosenblueth, Instituto Nacional de Cardiologia, Mexico City.

are constricted, and there is intermittent piloerection and shivering. Intravenous administration of soluble pentobarbital suppresses this mechanism for heat conservation and heat production, and reduces body temperature in the experimental animal to the normal level. These investigators suggested that the administration of intravenous barbiturate should be effective in cases of human hyperthermia following surgical or other injuries to the hypothalamus. (This has since been tried on numerous occasions and has unfortunately failed.) In contrast to excessive heat conservation produced by anterior hypothalamic lesions, Stoll[14] has found that bilateral electrolytic lesions placed more caudally in the central hypothalamus cause a complete loss of heat regulation with poikilothermia.

Interesting human cases of disturbed temperature regulation have been observed in the presence of tumors invading or compressing the hypothalamic nuclei. Davison and Friedman[15] have described a newborn infant with hydrocephalus whose body temperature fluctuated from 93° to 103° F. throughout the four weeks' course of its life. At post-mortem, in addition to generalized dilatation of the ventricles, most of the hypothalamic nuclei were found to be destroyed by an infiltrating neuroblastoma. A second patient, 31 years old, with mild diabetes insipidus, adiposogenital dystrophy, hypersomnia, and prolonged subnormal temperature, was studied by Davison and Selby.[16] For the last three months of his life the temperature had ranged from below 90° to 96.6° F. In this instance an angioma situated in the floor of the third ventricle had partially destroyed the rostral portions of the supraoptic and paraventricular nuclei, together with the right mammillary body. Disturbances in the sleeping-waking mechanisms also arise from lesions in the hypothalamus and neighboring structures (Davison and Demuth[17]).

While Heinbecker, White, and Rolf[18] produced obesity in dogs after removal of the pars distalis of the pituitary, it is probable that this was caused by concomitant injury to the inferior hypothalamus. Hetherington,[19] who reinvestigated this problem, concluded that the hypothalamic disorder is the sole factor involved. Brobeck, Tepperman, and Long[20] found that rats with injuries to the hypothalamus get fat because of their increased appetite. Cox[21] reported a case of voracious appetite with rapid gain in weight and increased somnolence in an 8-year-old boy after recovery from a severe head injury. He died from attacks suggestive of autonomic epilepsy, and post-mortem examination showed areas of gliosis just posterior to the hypothalamus and surrounding the aqueduct.

In his Balfour lecture of 1932, Cushing[22] first presented evidence that acute ulceration of the upper gastrointestinal tract may follow various cerebral lesions and operations which injure the parasympathetic centers in the hypothalamus. Strassmann[23] who made a post-mortem study of acute pathologic changes in the gastrointestinal tract, reported that gross lesions of the brain were absent in only two out of thirty cases of perforation of the esophagus or stomach. These patients had been in coma for hours or days before death and evidence of specific lesions to the hypothalamic centers is lacking. The type of cerebral pathology

ranged over a wide variety of acute and chronic conditions, including intracranial injury, vascular accidents, tumor, inflammatory lesions, and barbiturate poisoning.

Kennard[24] has shown that the highest centers of autonomic control are situated in the cortex of the frontal lobes and that the orbital surface is the control area for vagal representation. While she has observed the phenomenon of "sham rage" in cats following bilateral removal limited to the frontal lobes, in monkeys there were only temporary signs of increased sympathetic activity. Very little effect is seen in man. The reason for the different result in these three species must depend on the process of encephalization and upon the integration of emotion with the complex associative functions known to be represented in the frontal lobes. "In the simpler cortex of the cat these are more immediately related to segmental autonomic reactions than they are in man in whom all of the autonomic manifestations of the mechanisms of fight and flight have become minimized."

The fundamental problem of sensitization of denervated smooth muscle to adrenaline has been found to have less clinical importance in man than was at first suggested by animal experiments. Doupe,[25] however, confirmed the observation that denervated blood vessels are rendered abnormally sensitive to circulating adrenaline and pointed out that the reactions after peripheral nerve lesions are similar to those following sympathetic ganglionectomy. These observations bring the results of denervation in human beings into agreement with those in other mammals. He has also found a difference between the reactions of digital vessels following preganglionic and postganglionic sympathectomy. Fingers after complete degeneration of the peripheral nerves remain abnormally cold, due to the fact that there is both a lowered threshold and a more prolonged response to the action of adrenaline, whereas the vessels of preganglionectomized digits show only a lowered threshold. This chemical mediation of denervated blood vessels explains in part the peculiar early and late effects of peripheral nerve injury. Immediately following nerve transection the paralyzed extremity becomes hot and dry through interruption of the sympathetic components in the nerve trunk. However, as the severed fibers degenerate, the skin in the paralyzed area loses its initial vascular dilatation and becomes cool, although it remains dry. Doupe concluded that the diminished circulation of paralyzed fingers is due in large part to local sensitization of arteriolar smooth muscle to moderate cold. This sensitization to cold which takes place with degeneration of sympathetic innervation is made more manifest by the increased action of adrenaline and by disuse with secondary diminution in the formation of acid muscle metabolites.

Using the denervated finger as an indicator, Doupe[25] was able to make some interesting observations of the rate of adrenal secretion. Adrenaline was found to be liberated in response to psychogenic stimuli, whereas the need for heat conservation did not consistently evoke its secretion. It was found that adrenaline could be liberated in the body in amounts comparable to the rapid intravenous injection of 2 μg and for longer periods at the rate of 6 μg per minute. Under

other circumstances much larger amounts might be liberated and would suffice to initiate a persistent vasoconstriction of a denervated digit.

Richards,[26] who also studied the control of circulation in the hand after injuries to the peripheral nerves, reached exactly similar conclusions, except that he believed that the loss of axone reflexes contributes to the maintenance of the chronic cold phase.

While the secretion of sweat has long been ascribed to the action of hypothalamic stimulation of the sympathetic fibers, Bucy and Pribram[27] found its highest representation within the precentral area of the cerebral cortex in man. Reflex sweating, caused by a variety of stimuli, may be produced by spinal reflex arcs below the level of a complete transection of the spinal cord (List and Pimenta[28]). In several cases perspiration in paralyzed areas was so profuse that sympathetic ganglionectomy had to be performed for its relief. Doupe and Sharp[29] showed that sebaceous secretion, unlike sweating, continues unaltered after sympathectomy. By analogy with the growth of hairs and of the epidermis, it was concluded that sebaceous secretion is the result of a continuous growth of the cells in the sebaceous glands.

de Takats,[30] who tested the clotting mechanism by the response to heparin, found that it is under the influence of the autonomic innervation. Adrenergic stimuli arising under the influence of fear, nervous strain, and hemorrhage increase the tendency to thrombosis, whereas this is reduced by the cholinergic action of prostigmine.

Both overactivity and paralysis of the sympathetic thoracolumbar fibers have been mentioned as factors in the production of shock. The theory advanced by Cannon[31] and Freeman[32] assumes that the emergency function of the sympathetic nervous system, called into action by hemorrhage, fright, or pain, is at once a protecting and a damaging response—protecting in that it maintains the circulating blood volume of the vital centers, and damaging in that it causes peripheral capillary damage with loss of blood plasma from increased permeability. In recent animal experiments prolonged and intense vasoconstriction produced by Schafer[33] by resection of the aortic depressor and carotid sinus nerves failed to produce shock. These dogs tolerated hemorrhage in approximately the same manner as normal animals. Schafer stated that the experience at the University of Chicago fails to support the theory that sympathoadrenal hyperactivity may act as a cause of shock during injury or operation except in patients with a pheochromocytoma.

One of the oldest theories of traumatic shock is that excessive afferent stimulation may exhaust the vasomotor center and thereby produce a fall in blood pressure of such magnitude that the circulation becomes inadequate. Phemister and co-workers[34] tested this hypothesis in rabbits by inducing prolonged periods of hypotension at a shock level by stimulation of the aortic depressor nerve. Judging by the relative harmlessness of long periods of low blood pressure, by the inability to produce more than a brief slight lowering of blood pressure by direct stimulation of somatic nerves, and by the comparatively short duration of reflex lowering of blood pressure during syncope and

abdominal manipulations, it is extremely improbable that "primary shock" is ever produced in man by the action of afferent depressor nerve impulses.

Another physiologic finding of fundamental interest in connection with hemorrhagic shock, the crush syndrome, and transfusion reactions is the neurogenic alteration in renal blood flow described by Trueta and his co-workers[35] at Oxford. Experiments on animals, both with the abdomen unopened and with the kidneys exposed, have demonstrated the development of cortical ischemia through a neurogenic mechanism. Arteriograms taken at the time of stimulation of the nerves in the renal pedicle show complete shut down of circulation in the cortical glomerular zone. The simultaneous appearance of pulsating red arterial blood in the renal vein indicates a short-circuiting of the blood in the medullary subcortical vessels while the circulation through cortical glomeruli is entirely cut off. Under these circumstances the secretion of urine decreases or may be entirely suppressed. If this mechanism is confirmed, further work along these lines may demonstrate that certain varieties of postoperative, traumatic, and toxic uremia may be amenable to splanchnic block, and also that this mechanism may be concerned in the etiology of essential hypertension.

TESTS

Therapeutic sympathectomy cannot be utilized intelligently without preliminary evaluation of the degree of vasoconstrictor tone. In cases of peripheral vascular disease there is often both a functional element of vasospasm and an organic element of vascular obliteration. It is therefore important to find out the degree to which neurogenic constriction predominates. This has been done in the past by blocking the sympathetic vasoconstrictor outflow in the peripheral nerves, paravertebral rami, or anterior spinal roots by injecting procaine hydrochloride.

Differential spinal block, a refinement of spinal anesthesia, has been developed by Sarnoff and Arrowood.[36] By gradual injection of 0.2 per cent solution of procaine into the lumbar subarchnoid space it is possible to block the spinal root fibers carrying vasoconstrictor impulses and also those concerned with pain and temperature sense without materially affecting fibers concerned with touch, proprioception, vibratory sense, or motor power. This differential blocking of the anterior root fibers probably depends on the size of the fibers and their degree of myelinization, the fine, poorly myelinated axones, which carry sympathetic, thermal, and pain-conducting impulses, being the first to be impregnated by the drug. The fall in blood pressure is not the result of muscular flaccidity or diminished thoracic excursions, but a specific result of the interruption of sympathetic vasoconstrictor fibers. By gradually raising the level it is possible to produce a vasomotor and sudomotor block of the entire body. This technique has proved to be a safe and simple method of determining the degree of vasospasm. Southworth and Russek[37] have advocated the caudal or epidural injection of procaine to block the lower portion of the thoracolumbar vasoconstrictor outflow, but this is both more difficult from a technical and less specific from a physiologic viewpoint. (Preliminary observations at the

Massachusetts General Hospital have not confirmed the hope that these methods would be helpful in the preoperative testing of hypertensive patients.)

An entirely new method of testing the effect of sympathectomy by blocking synapses between the pre- and postganglionic autonomic neurones (both sympathetic and parasympathetic synaptic transmission is blocked) has been developed as a result of the study of Acheson and Moe[38] on the pharmacologic action of tetraethylammonium chloride and bromide at Harvard Medical School. Clinical evaluation of the drug, administered by intravenous or muscular injection, was carried out by Berry and his co-workers[39] at the University of Michigan. This demonstrated the efficiency and safety of the drug in producing a blockade of the autonomic ganglia to a degree comparable with that obtained following the usually accepted methods of sympathetic block. These investigators reported useful diagnostic and even therapeutic results by single or repeated injections in 500 patients with peripheral vascular disease, posttraumatic painful syndromes in the extremities, and hypertension. (Preliminary studies at the Massachusetts General Hospital, however, have shown a far greater tendency for the blood pressure to fall after administration of the drug than after radical resections of the thoracolumbar chains and splanchnic trunks.)

Despite the accurate evaluation of the degree of acute dilatation which is gained by all of these methods, it is still desirable to find a method of more prolonged diagnostic block of the vasoconstrictor fibers. Only in this way can the surgeon who deals with peripheral occlusive vascular disease gain an idea of the long-term improvement in collateral circulation which often develops gradually after sympathectomy. Promising efforts toward developing temporary but longer lasting paravertebral sympathetic block of the vasoconstrictor fibers for use in preoperative testing of patients with thromboangiitis obliterans and arteriosclerosis have been reported. Lee, Macht, and Pierpont[40] used 4 per cent monobromhydroxybenzyl alcohol in peanut oil and Rasmussen and Alessi[41] 5 per cent benzyl alcohol and propylamine-benzoate in procaine. The resultant vasoconstrictor block has lasted from several days up to a maximum of several months.

In cases of traumatic injuries of the larger arteries, wartime experience has shown that increased vasomotor tone hinders the development of adequate collateral circulation. As Rector[42] has stated, "The majority of patients who presented clinical evidence of high vasomotor tone as shown by cyanosis, sweating, and constricted veins developed symptoms of vascular insufficiency unless they were subjected to sympathectomy. By comparison, those with a low or normal vasomotor tone appeared to develop collateral circulation spontaneously." A simple method of separating individuals into these categories was suggested by Naide and Sayen.[43] This consists of observing the cutaneous temperature response of the finger tips under standard cooling conditions. Individuals are classified as having "a high grade of vascular tone if the hands are cool (below 25° C.) 15 minutes after the patient has been in a constant temperature room at 20° C., unclothed except for a light gown. . . . If, on the contrary, the hands remain warm (25° C. or above) after this same exposure,

the patient is in a low vascular tone group." The majority of individuals with a high grade of vascular tone do not develop an adequate collateral circulation after occlusion of major arteries. These constitute the group of individuals who respond well to sympathectomy, whereas those with a low vascular tone are not strikingly benefited.

The application of skin resistance measurements has greatly simplified previous methods of mapping the extent of interruption of the sympathetic fibers to the skin. The resistance offered to the passage of a minute, imperceptible, direct current through the body is localized almost entirely in the skin. Cutaneous resistance is controlled largely by the activity of the sudomotor impulses and therefore depends on the sympathetic components of the peripheral nerves. Simple portable "dermometers" have been described by Richter[44] and Jasper.[45] Denervated skin (after either paravertebral sympathectomy or injury to the peripheral nerves) shows a marked increase in electrical resistance which remains at a relatively high level unless neurotization takes place. The method, which was studied intensively by Richter and associates,[46-48] is an objective, practical, and precise test for mapping out the sympathetic dermatomes or the area of peripheral nerve degeneration, and also gives evidence of subsequent regeneration.

Previous methods of mapping areas of sweating have consisted of the color reactions of cobalt chloride, quinizarin, and the starch iodine reaction. An improvement in bringing out the details of the sweating pattern, which makes it possible to visualize the orifices of the individual glands, was devised by Silverman and Powell.[49] This is extremely simple and consists of painting the skin with tincture of ferric chloride. On dusting tannic acid powder onto the skin or pressing the sweating surface against paper impregnated with tannic acid, the smallest droplets of sweat turn black as the iron and tannic acid unite to form ink. Photographs may be taken if permanent records are desired.

SYMPATHECTOMY IN PERIPHERAL VASCULAR DISEASE

The value of sympathectomy in many forms of peripheral vascular disease is still a highly controversial subject. If interruption of the peripheral sympathetic fibers dilates only the cutaneous vessels and fails to release the much more important arterial tree in the muscles, sympathectomy would not be justified, either for the treatment of threatened peripheral gangrene or intermittent claudication. Under such circumstances the pooling of blood in the relatively unimportant cutaneous bed would actually starve the muscles and favor the onset of a Volkmann lesion (Cohen,[50] Siddons[51]). Through ingenious human experiments, Barcroft and Edholm[52] proved that this is fortunately not the case. By measuring the circulation through the human forearm with the plethysmographic technique, these investigators have reached the conclusion that blood flow in acutely denervated mucles is more than doubled. After sympathectomy, however, there is a gradual return of vasoconstrictor tone in about a week. Vasodilatation, which normally takes place in the muscles of the forearm after fainting, does not occur in sympathectomized extremities. During syncope there is active vasodilatation in the normally innervated extremity, as the blood flow

increases to a greater extent than in the acutely denervated arm. It is also noteworthy that release of sympathetic tone cannot explain the increase in circulation during exercise.[53] Release of vasoconstrictor tone in muscles would probably increase blood flow by about 1.5:1, whereas in strenuous exercise the increase is nearer 20:1. It is therefore evident that sympathectomy should be of value in preventing acute gangrene after injury to the major arteries of an extremity. It should likewise help in the treatment of threatened gangrene in peripheral vascular disease, even though it may not improve the walking capacity in intermittent claudication. Such theoretical conclusions fit well with clinical observations.

Direct measurements of capillary blood pressure have been made by Eichna[54] before and after preganglionic sympathectomy in cases of Raynaud's disease and scleroderma. He found a striking rise of pressure in the arteriolar limb (9.3 mm. of mercury) and the establishment of a more favorable pressure gradient, which is generally low in the abnormally dilated capillary loops in the presence of chronic digital ischemia. The abnormal capillaries with slowly flowing, bluish-red blood became smaller and narrower, with rapidly flowing, better oxygenated blood. This change was attributed not to the removal of sympathetic innervation per se but to the improvement in digital circulation which followed the abolition of periods of circulatory arrest.

Grimson[55] made a careful review of the causes that impair the results of sympathectomy in the upper extremity. In the first place, man with his upright posture has a lesser degree of vasoconstrictor tone in the arm than in the leg. Hence upper thoracic sympathectomy is not followed by such a striking increase in blood flow as follows resection of the lumbar ganglia. Several other factors are involved in the inferior late results. The inherent ability of smooth muscle of blood vessels to maintain an independent tone probably limits the general effectiveness of sympathectomy more than any other single factor. The sympathetic nerve supply largely modulates, but only partially maintains vascular tone. Following total or near-total sympathectomy or high transections of the spinal cord, there is a striking acute fall in blood pressure and a severe degree of postural hypotension. These effects do not last long. It is therefore difficult to avoid the conclusion that the regain of tone results from an intrinsic property of smooth muscle, although why residual tone should be so much greater in the hand than the foot is not explained on this basis.

Another factor which militates against the prolonged effectivenes of upper extremity sympathectomy is nerve regeneration. Severed preganglionic sympathetic fibers have an extraordinary ability to re-establish connections with other remaining ganglia, even over a considerable gap. When a 5 cm. length of lumbar chain is removed regeneration is rare, but after the less extensive gap which is achieved after the usual operation for the upper extremity, recovery is not uncommon. Kirgis and Ohler,[56] who investigated this problem in cats, were able to find regenerating fibers bridging the operative gap within a period of four months. These findings emphasize the necessity of taking special measures to obviate re-establishment of functional connections by preganglionic fibers with upper thoracic ganglia when the latter are not extirpated. They also

demonstrate the futility of removing such a limited area as the second thoracic ganglion, as recommended by Goetz and Marr.[57] (At the Massachusetts General Hospital some fifteen years ago removal of the second and third thoracic ganglia was carried out in three patients with Raynaud's disease of the upper extremity. Although the early results were all that could be desired, all had recurrences within one year.) Grimson,[55] who reviewed the relative value of pre- versus postganglionic sympathectomy for increasing circulation in the upper extremity, reached the conclusion that the "adrenaline sensitization" phenomenon, upon which the preganglionic type of sympathectomy is based, is not sufficiently important clinically to warrant the risk of regeneration. He employed the preganglionic operation only in cases of poor circulation in a single arm in order to avoid the disfiguring effect of a unilateral Horner's sign. Illustrating the frequency of relapses following preganglionic sympathectomy in Raynaud's disease of the upper extremity, Telford[58] admitted that only sixteen out of thirty-seven patients maintained their original improvement in circulation some years afterward. While he was not convinced that these late recurrences are necessarily due to regeneration, Simmons (cited by Telford), who made a careful study of the problem in his clinic, reached this conclusion.

Recent evaluations of sympathectomy in cases of peripheral vascular disease have brought out the following points:

Shumacker[59] stated that in his hands sympathectomy gives excellent results in the treatment of Raynaud's disease and other purely vasospastic states. In a small proportion of cases there were no further attacks from emotional stimuli, but the extremities continued to cool abnormally on exposure to cold. Late cases with subcutaneous fibrosis and digital ulceration responded less well than those with early uncomplicated Raynaud's phenomenon. However, he believed that improvement will take place in most instances of scleroderma, although in the more advanced cases progress of the disease will only be stopped or definitely slowed. In general the good effects of sympathectomy can, as pointed out previously, be fairly well assayed by careful preoperative tests. The fact that severe scleroderma may become a generalized disease with visceral as well as cutaneous involvement has been disclosed by reports of clinical and post-mortem examinations published by Goetz[60] and Pugh and associates.[61]

Other conditions with a primary underlying element of vasospasm in which impressive results have been recorded in recent reports include acrocyanosis, pernio,[58] and the vasomotor disturbances which often follow poliomyelitis (Telford,[58] Collins and co-workers[62]). Telford[58] claimed that even in erythromelalgia he was able to obtain good results, although the reason for this is far from clear.

Further confirmation has been given by Shumacker[59] and others (Trimble and associates,[63] Gautier,[64] Telford and Simmons,[65] de Takats and co-workers[66]) that selected cases of thromboangiitis obliterans and other varieties of obliterative arterial deficiency may be justifiably submitted to sympathectomy by surgeons experienced in this field. Shumacker also drew the interesting conclusion that any patient with obliterative arterial disease who has significant superimposed

vasospasm can be treated more effectively and with a shorter period of hospitalization by sympathectomy than by more prolonged daily treatment with the pavex boot, intermittent venous occlusion, various sorts of intravenous injections, and other varieties of so-called conservative measures. Time and money-saving are most important considerations to patients, many of whom come for help only after they have been impoverished by prolonged medical treatment and inability to work.

Past reports have led to considerable confusion in regard to the increase in walking tolerance which results from sympathectomy in patients with Buerger's disease and arteriosclerosis. A number of encouraging experiences have been published in the last four years (Trimble and associates,[63] Telford and Simmons,[65] de Takats and associates[66]). The results, as might be expected, are not as good in arteriosclerosis as in thromboangiitis obliterans (Barringer[67]). It may be concluded that lumbar sympathetic ganglionectomy is well worth a trial if there is concomitant evidence of increased vasomotor or sudomotor activity, or if exercise tolerance increases as a result of diagnostic paravertebral block. While only a certain number of patients are entirely relieved of their pain, many are benefited, and even the failures usually show other worth-while evidence of improvement such as warmer feet, elimination of sweating, etc.

Traumatic Arterial Injury.—The tendency of long segments of arteries to go into spasm following local thrombosis or trauma has long been stressed by Leriche.[68] Spasm of this sort may be so intense that collateral circulation fails and the limb is threatened with gangrene. Learmonth[69] gave an interesting discussion of this subject, showing that neither complete interruption of sympathetic vasoconstrictor impulses nor the reflex mechanism of heating the remainder of the body can be counted on to release the spasm. Similar observations were made by Siddons.[51] Learmonth stated that "it is undoubtedly possible . . . for a thrombosed segment of artery to impose spasm on its collateral circulation when the limb is denervated." He described a number of instances in which resection of the injured portion of the artery restored an adequate circulation through the collateral bed.

Once the source of traumatic vasospasm has been removed by adequate local surgery in penetrating battle wounds, the recent wartime experience of American Army surgeons has favored repeated postoperative injections of the sympathetic ganglia with procaine. Rose, Hess, and Welch[70] advocated a first injection at the close of the operation followed by repeated blocks at six- to twelve-hour intervals until the fate of the extremity is established. They also suggested injection with 5 c.c. of 95 per cent alcohol when the procaine block was effective. DeBakey and Simeone,[71] who reviewed the statistics of arterial injuries in the recent war, stated that from their analysis there is "no substantial evidence that this method [chemical block] was of any value. The incidence of amputation in the group in which sympathetic block was performed is only slightly less than the incidence for the group as a whole, while the incidence in the cases in which ganglionectomy was done is greater than for the entire series." They explained, however, that familiarity with the material

permits a different, more accurate interpretation. Sympathectomy, as a rule, was used only as a last resort, while sympathetic block was instituted more frequently as part of the immediate postoperative routine. They therefore concluded that there is considerable evidence in favor of both sympathectomy and sympathetic block in these arterial injuries and that the experience of most American surgeons is to the effect that both methods were "useful and beneficial procedures, regardless of inconclusive statistical evidence to prove the point."

The results of sympathectomy in the prevention of late arterial deficiency as manifested by coldness, ulceration, and intermittent claudication which so often follows ligation of the major arteries in the upper leg have been definitely encouraging (Kirtley,[72] Crutcher[73]). Recent experience has also shown that preliminary sympathectomy is of unquestionable value for the safe surgical resection of aneurysms and arteriovenous fistulas (Kirtley,[72] Richards and Learmonth,[74] Linton and White,[75] Harbison[76]).

A final type of war lesion in which the value of sympathectomy remains of debatable value is the so-called trench and immersion foot. After prolonged exposure to mild freezing and thawing, as occurred so frequently during the campaigns in Attu, northern Italy, and Europe, or in the course of prolonged immersion after torpedoings in the North Atlantic, the preliminary reaction of the injured feet was an intense hyperemia. In the late phase, however, the feet developed deep tissue fibrosis with persistent ulceration, and they were often sweaty, painful, and excessively sensitive to cold. Hyperhidrosis often led to maceration of the skin and chronic secondary infection. Resection of the lumbar ganglia has a limited value in the late phase, as it stops the excessive sweating, tends to reduce the sensitivity to cold, but is unlikely to diminish pain (Shumacker and Abramson,[77] Kirtley,[78] White and Scoville[79]).

Treatment of Thrombophlebitis by Sympathetic Block.—Treatment of phlegmasia alba dolens in the acute stage by chemical block of the sympathetic outflow to the lower extremities was first proposed by Leriche in 1927 and popularized in this country by Ochsner and DeBakey. In a recent discussion of venous thrombosis, Ochsner[80] gave a clear description of the two varieties of this condition. In phlebothrombosis, where the thrombi are loosely attached to the walls of the veins and there is no superimposed arteriolar spasm or block of the lymphatics, symptoms are minimal, but the danger of death by pulmonary embolism is great. In deep thrombophlebitis, on the other hand, there is often prolonged incapacity and much discomfort from fever, vasospasm, edema, and pain. This results in the classical picture of phlegmasia alba dolens. Ochsner explained the paradox of a white, cold extremity in the presence of pyrexia and elevation of surface temperature in the other uninvolved extremities on the basis of arteriolar spasm. Because the symptoms and signs are due to spasm of the arterioles with secondary ischemia and increase in capillary permeability, vasodilatation by chemical interruption of the regional sympathetic ganglia with procaine is rational. By daily repetition of the block until the fever subsides, the symptoms and signs are quickly alleviated and the postphlebitic sequelae of prolonged pain, edema, and ulceration eliminated. The painful ischemia is

relieved at once. Sixty-two per cent of Ochsner's patients were able to leave the hospital within eight days and only 10 per cent remained on the wards after twelve days.

De Sousa Pereira[81] and also Papper and Imler[82] have attempted to show that there is also active reflex constriction of the veins in thrombophlebitis. The importance of sympathetic innervation of the veins is still uncertain. While numerous nerve fibers are present in their walls, it is not known how active a role they play in regulating their caliber. Definite dilatation of the veins of patients with thrombophlebitis is clearly shown in contrasting venograms taken before and after procaine block which are reproduced in these two papers. This clear demonstration of increased venous flow, although most convincing evidence of the therapeutic value of procaine block, does not prove that the increased diameter of the veins is due to release of spasm in their walls. Exactly the same result would follow increased arterial inflow and secondary distention. De Sousa Pereira, however, illustrated an increase in caliber of the internal saphenous vein in phlebograms taken before and after the intravenous injection of 15 c.c. of procaine in a single patient. This should not have increased arterial inflow and therefore constitutes fairly convincing evidence that a certain degree of active neurogenic venous constriction may be present.

Treatment of Polycythemia Vera by Total Sympathectomy.—The intriguing possibility that polycythemia may be treated surgically by radical sympathectomy has been suggested recently. In an experimental study, Schafer[83] found that dogs, following denervation of the carotid sinus and section of the cardio-aortic depressor nerves, became not only hypertensive but also developed polycythemia. After extensive resections of the paravertebral sympathetic chains these animals had a significant decrease in the red cell mass and total blood volume, as well as a reduction in hypertension. Support is given to the theory that the formation of red blood cells by the bone marrow is under the control of the sympathetic nervous system and that some cases of polycythemia in man are due to contraction of the perisinusoidal blood vessels in the bone marrow. The case of a 27-year-old man with intractable polycythemia rubra vera is presented and the striking effect of bilateral removal of the paravertebral ganglionated chains from the first thoracic to second lumbar inclusive and the splanchnic nerves is recorded. Immediately following surgery the total blood volume, red cell mass, hemoglobin, and hematocrit fell abruptly, and then gradually increased in a space of two years to approximately their preoperative values. This recurrence took place with the regeneration of nerves to the sweat glands and is presumably due to a partial recovery of bone marrow innervation. It is of interest that despite the return of objective evidence of the disease the patient remained symptom-free and able to work strenuously as a hospital orderly for fourteen hours a day for a period of three years.

VISCEROMOTOR DENERVATION

Carotid Sinus Syndrome.—Reflex adjustments of blood pressure and cardiac rate are largely effected by an autonomic proprioceptive mechanism mediated by the pressoreceptor innervation of the carotid sinus. Current knowledge of

this subject has been well reviewed in an editorial of the *Journal of the American Medical Association*.[84] Attacks due to a hyperactive carotid sinus reflex may result in syncope or convulsions due to cardiac asystole or primary reflex depression of the blood pressure.

The syndrome is most common in males, increases with advancing age, and is often related to coronary disease. In Nathanson's[85] study of 115 patients with a hyperactive carotid sinus reflex, only twenty-three had clinical symptoms and only four had attacks of sufficient severity to cause actual incapacity. Nathanson believed that it is not the afferent arc (glossopharyngeal) that is hypersensitive, but the vagus center in the medulla. This localization of the site of sensitivity is of more than theoretical significance, as a certain number of failures of sinus denervation may be explained by an hyperactive response of the vagus to stimuli from other proprioceptive-depressor areas, such as the aortic arch.

Value of Vagus Resection in the Treatment of Peptic Ulcer.—Experimental work performed by Dragstedt and Owens[86] suggested that among other factors the corrosive action of gastric juice is responsible for peptic ulcer. Some ulcer patients display an excessive secretion of gastric juice in response to stimulation by food, histamine, and alcohol. A considerable number secrete large amounts when there is no obvious stimulant, such as between meals or at night. In addition to hyperacidity one occasionally finds increased motility. Both these abnormal factors are probably neurogenic in origin and may be reduced by total interruption of the vagi. Many physicians have called attention to the high incidence of ulcer in individuals whose occupations subject them to continuous mental strain and anxiety, and to the tendency for exacerbations to occur during periods of emotional stress. These observations suggest the possibility that ulcer is a psychosomatic disorder (Dragstedt[87]). The earlier observations of Cushing showed that acute ulceration and perforation of the stomach could take place with lesions in the region of the hypothalamus, the higher center of visceral control. Increased activity in the hypothalamic parasympathetic centers induced by psychic disturbances in the frontal lobes therefore is probably one etiologic factor in this disease.

In a study of secretion in various forms of gastric pouches in dogs, Weinstein and associates[88] found that only in the Heidenhain type of pouch, in which all the vagal fibers are divided, is neurogenic secretion totally abolished. The fact that copious secretion is maintained in partially denervated pouches is evidence of an important principle in surgery of the autonomic nervous system, namely, that any denervation to be effective must be complete (White and Smithwick[89]). Smithwick,[4] who has reviewed this subject, pointed out that early attempts at partial vagectomy in the treatment of peptic ulcers failed for this reason.

The anatomic arrangement of the vagal trunks along the lower esophagus and their distribution to the stomach was well described by Bradley and his colleagues at the Mayo Clinic.[90] Dragstedt[91] outlined the technical procedures for complete division of all the vagal rami to the stomach. This can be performed by either a transthoracic or an upper abdominal approach. While a

greater length of the vagal trunks can be removed by the former route, the latter is of advantage when it is desirable to explore and resect a questionably malignant gastric ulcer, and also when it is necessary to perform a gastroenterostomy or resection for relief of pyloric obstruction.

After the supradiaphragmatic transthoracic resection of the vagi along the lower esophagus, as proposed by Dragstedt and his co-workers,[91, 92] the following alterations in gastric physiology have been observed: the operation has no effect on the secretory response of the stomach to histamine or food, but abolishes the stimulating effect of insulin hypoglycemia or a sham meal. The abnormally copious continuous secretion of gastric juice at night in the empty vulnerable stomach is reduced from 50 to 60 per cent. There is also a great reduction in free and combined gastric acidity, and the excessive tonus and hunger contractions are decreased.

By the end of 1946, ninety vagotomies had been reported by Dragstedt,[87] eighteen by Grimson,[93] and fifteen by Moore and co-workers.[94] The latter have given particularly clear and impressive evidence of the postoperative changes which lead to healing of the ulcer. The first twelve of Dragstedt's patients, followed for three years, remained well, took no medication, and were under no dietary restrictions. The nocturnal secretion of gastric juice was still within the normal range and tests of gastric secretion by the sham meal and insulin hypoglycemia showed that regeneration of the secretory fibers in the vagi had not yet occurred.

Moore and associates[94] discussed the indications and contraindications for vagotomy. The most favorable group of individuals for this operation is made up of young or middle-aged men with a long history of peptic ulceration, possibly with previous perforation or hemorrhage, unobstructed and not bleeding acutely, who have been refractory to careful medical therapy, and who have severe ulcer pain in times of stress, which can be relieved temporarily by the usual antacid, milk, or food. Gastric ulceration proximal to the pylorus should be approached with the greatest caution because of the difficulty of distinguishing ulcer from cancer. Resection should therefore usually be employed in such cases. Patients who have had previous surgery, such as pyloroplasty, posterior gastroenterostomy, or gastric resection, and who present themselves with renewed ulceration, are the most suitable subjects for this procedure. The operation is contraindicated in acute perforation, massive hemorrhage, or advanced cicatricial obstruction. Its mortality rate has been remarkably low.

Before any final evaluation can be made of the ultimate value of vagotomy, many more cases must be studied and more time must pass for nerve regeneration and recurrent ulceration from other causes to become manifest. Papers published in 1947 already give evidence of unsatisfactory features about the operation which were not stressed in earlier publications. From his own experience up to this date at the Massachusetts General Hospital and from correspondence with others, Moore found that vagotomies have now been performed in nearly 1,000 patients. In two recent papers[95, 96] he reached certain opinions which, even though out of place in a review of this four-year period, must be

included here in order to present a judicial evaluation of this new and important subject. These recent observations bring out a 10 to 15 per cent incidence of annoying postoperative symptoms, especially diarrhea and sensation of "fullness" with odoriferous eructation. There is already a known incidence of recurrent ulceration in 5 per cent of patients. Though both disagreeable side-effects and recurrences have been observed in all surgical and medical therapies for ulcer, the final usefulness of vagotomy must depend on the relative frequency of its ill effects. These, as Moore pointed out, are just coming to the surface.

The role of the sympathetic innervation of the stomach is of far less importance than the vagus, as the splanchnic nerves carry mainly vasoconstrictor and sensory fibers. To a certain limited extent they exert an antagonistic effect on the vagi, and excessive activity on their part might lead to spasm of the cardia and pylorus with atony of the stomach. No changes in gastric secretion would be expected, but generalized or local vasoconstriction and stasis might result (Dragstedt[87]). The idea that peptic ulceration is due to local ischemia of the gastric mucosa has been proposed and in recent years an attempt has been made in France (Froelich[97]) to treat duodenal ulcer by sympathectomy. While this operation is known to relieve gastric distress, the release of unopposed vagal activity carries with it the risk of acute perforation. This complication has led to a fatal result reported by Weeks, Ryan, and Van Hoy.[98]

Neurogenic Dysfunction of the Gastrointestinal Tract.—Evidence is lacking to prove that the sympathetic fibers play an important antagonistic role to counteract the peristalsis-promoting, sphincter-controlling action of the vagi and sacral parasympathetic nerves. Nevertheless, the similarity of esophageal dilatation secondary to cardiospasm and megacolon, which is occasionally accompanied by great dilatation of the ureters as well, suggests that the idiopathic enlargements of the hollow viscera are of neurogenic origin. Furthermore, degenerative changes have been found in the plexus of Auerbach in megacolon (Penick[99]).

The value of sympathectomy, however, remains extremely questionable in these conditions. In cardiospasm, Eggers[100] concluded that it is not justifiable to advocate extensive neurosurgical procedures, as evidence is lacking that sympathetic denervation can benefit patients with advanced degrees of a disease in which mechanical factors are so prominent.

The same viewpoint may also apply to the treatment of megacolon, as Scott and Serenati[101] pointed out. In this condition they believe that there are two clinical groups. In one the interference in emptying of the bowel is primarily neurogenic in origin, whereas in the other it is due to mechanical obstruction from the kinking of an abnormally long colon. Evidence that certain cases are primarily of neurogenic origin is their response to parasympathetic stimulating drugs and the evacuation of the dilated lower bowel by spinal anesthesia. These writers advised sympathectomy in the small group of patients who respond dramatically to spinal anesthesia, but fail to gain sufficient relief from this and other forms of conservative treatment. When an extreme redundancy of the

colon with kinking exists and conservative methods are ineffective, they recommend resection of the redundant colon combined with left lumbar sympathectomy. They have not yet proved whether this combination offers more than resection alone.

If sympathectomy is to be undertaken, surgeons are not in agreement as to the best type of denervation. This is brought out in Midon's[102] extensive review of the literature, in which the results of a half-dozen different operations are recorded. These include resection of one or both lumbar chains with or without the added removal of the splanchnic nerves, as well as several varieties of presacral neurectomy and resection of the inferior mesenteric plexus. The most interesting and convincing discussion of sympathetic denervation was given in a paper by Penick.[99] He summarized the results in eleven patients from the department of surgery at Tulane treated by left lumbar sympathectomy, in seven of whom highly satisfactory results were obtained. Three others were greatly improved, although occasional cathartics or enemas were still required. The remaining very advanced case was a complete failure. Essentially the same figures were obtained from 178 cases he abstracted from the literature. Penick therefore favored a trial of left lumbar sympathectomy in children who have reached the age of 3 without improvement on a medical regime and in whom spinal anesthesia produces a copious bowel movement. Should this fail, one has to decide whether the right lumbar chain or the splanchnic trunks are to be resected as well. In the discussion of this paper Bargen commented on the fact that extensive bilateral operations may cause sterility in males, and that unfortunately in this condition males predominate over females in the ratio of 5:1. When all these factors are kept in mind the operation is bound to have a limited application, as the results of resection are uniformly good and permanent, although at the risk of a distinctly higher mortality rate.

A recent French publication by Luzuy[103] contained the interesting suggestion that pylorospasm in infants is of neurogenic origin and can be treated by repeated splanchic block with procaine.

VISCEROSENSORY DENERVATION

Although the pioneer work of Bernard, Gaskell, Langley, and Cannon has defined the function of the autonomic nervous system as purely a motor mechanism for the control of homeostasis, all its visceral rami nevertheless carry large numbers of sensory fibers. These differ structurally from the visceromotor fibers because they are more heavily myelinated, leave the spinal cord in the posterior roots, and run to their sensory end organs without any ganglionic synapse. Posterior root section, paravertebral ganglionectomy, or interruption of the peripheral trunks and plexuses are all capable of relieving pain in otherwise intractable visceral disease.

Angina Pectoris.—Now that interest in Beck's attempts to increase coronary circulation by muscle grafts has waned on account of its excessively high rate of mortality (37.8 per cent according to Feil[104]), and since total thyroidectomy

has also fallen into disfavor, the neurosurgical control of cardiac pain appears to be the most effective method of treating the rare sufferer from angina pectoris who cannot be controlled on a medical regime and cannot be freed from the nervous and physical exhaustion caused by continued pain and loss of sleep.

In their large series of cases White and Smithwick[89] showed that ipsilateral precordial and arm pain are constantly relieved after excision of the upper three thoracic sympathetic ganglia or effective interruption of their cardiac rami by chemical block with alcohol. Statistics from other neurosurgical clinics in this country also show that laminectomy and section of the upper four thoracic posterior roots will give equally effective results. A complete analysis of these cases will soon be published by White and Bland. In brief, surgical interruption of the sensory fibers to the heart is highly effective, although it carries a greater mortality risk (10 per cent) than the injection with alcohol. On account of the technical difficulty in obtaining perfect accuracy of injection, the latter gives results comparable with operation in only two-thirds of the cases. As it may also produce a temporary but disagreeable intercostal neuralgia, it should be reserved for those patients who present too serious an operative risk.

Less extensive cardiac denervations, such as removal of only the stellate ganglion, result in a considerable proportion of failures because they leave intact accessory pain fibers in the thoracic cardiac nerves. Gallavardin and Froment,[105] in summarizing their series of thirty cases of limited stellectomy, reported excellent lasting relief of pain in one-third, moderate improvement in a second third, and failure in the remaining third. Wertheimer,[106] who used the more extensive anterior exposure to the stellate ganglion recommended by Gask and Ross[107] and thereby was able to remove the second and possibly third thoracic ganglia as well, had correspondingly better results—twenty-eight cases with seventeen good results, four failures, and four deaths, with three others with inadequate follow-up.

Another type of cardiac denervation was recently proposed by Fauteux,[108] who utilized a direct exposure of the heart with pericoronary neurectomy and additional ligation of the coronary vein. In sixteen reported cases there was the high proportion of three deaths "during or rapidly after operation" and one soon after from progressive cardiac failure. Although the results in the survivors séem to have been satisfactory, one is led to wonder whether there will not be rapid regeneration of the pericoronary rami and whether the mortality rate of an operation comparable in extent with Beck's will not be prohibitively high. Only if ligation of the coronary vein leads to a significant increase in myocardial circulation can this transthoracic operation on the heart be superior to the far more innocuous and simpler interruption of its nerves in the posterior paravertebral space. (From experience with vein ligation in other forms of obliterative vascular disease and from recent, as yet unpublished, measurements made on experimental animals and man at this hospital by F. A. Simeone and W. H. Sweet, this seems most unlikely.)

The explanation as to why sympathectomy and posterior rhizotomy have relieved angina pectoris probably lies in the de-afferentiation of the heart. In the past the question has often been raised as to whether the clinical improve-

ment could not be explained better on the basis that cardiac sympathetomy also results in coronary dilatation. This would imply that the coronary vasoconstrictor fibers run in the sympathetic and is based on past uncertainty concerning the pathway of vasomotor nerves to the heart. Gregg,[109] who reviewed this subject, concluded that constrictor fibers predominate in the vagi and that coronary flow increases with sympathetic stimulation, although this effect can be accounted for, in part at least, by the increased work of the heart with the consequent increase in local production of metabolites. Since the heart can also increase its activity and coronary blood flow by the direct action of adrenaline, as well as by vagal inhibition, sympathectomy does not have any deleterious effect. In all the cases that have been submitted to this operation there has been no evidence of subsequent impairment of cardiac function.

Pain From the Abdominal Viscera.—A new field of surgery for the relief of intractable gastrointestinal pain has been opened in the last few years, and credit for most of the pioneer work is due to Leriche and his school in France. The monographs of Servelle[110] and Luzuy[103] give an interesting description of the conditions in which the sensory conduction of the splanchnic and other thoracic sympathetic trunks has been tested and the great value of temporary chemical block with procaine in the experimental study of human pain. Of particular importance are the studies of Mallet-Guy and Guillet[111] on the innervation of the biliary tree and pancreas. These surgeons in Lyons have studied the contractions of the gall bladder by direct observation in dogs and by cholecystography in man. It is evident that the splanchnic trunks inhibit contractility of the biliary tree which, together with relaxation of the sphincter of Oddi, is increased by vagal stimulation. These findings have been corroborated in this country by Johnson and Boyden[112] in experiments on cats. A series of twenty-three patients with biliary stasis treated by injection or resection of the right splanchnic nerve showed definite improvement in gall bladder emptying and relief of pain. Similar relief of otherwise intractable pain due to distention of the liver capsule by carcinoma and postoperative constriction of the biliary ducts have been reported by White and Smithwick.[89]

Chronic pancreatitis with fibrosis and calculi blocking the ducts is another cause for severe bouts of epigastric pain. Although this condition is amenable to cure by pancreatectomy, the extent of the disease or poor condition of the patient may make such a radical procedure extremely dangerous, if not impossible. Mallet-Guy and associates[113] have treated ten such cases with splanchnicectomy, with nine successful results and a single recurrence after five months. At the Massachusetts General Hospital four further cases of pancreaticolithiasis have been treated in similar fashion with equally striking results. One of these patients had residual pain on the side which was not operated upon nearly one year after a unilateral denervation. We have felt it wise to employ more extensive thoracolumbar resections of the ganglia and splanchnic trunks than is possible through the infradiaphragmatic operation used by Mallet-Guy, and feel that nerve regeneration is the probable explanation for his single failure.

Although pain from the stomach and intestines can usually be treated effectively by direct surgical attack on the lesion itself, experimental observations made in dogs have shown that afferent impulses from the stomach (Balchum and Weaver[114]) and the upper small intestine (Herrin and Meek[115]) are transmitted over the greater splanchnic nerves.

Chronic intractable attacks of renal colic in which there is no pathologic explanation for the pain, which can be simulated by retrograde distention of the renal pelvis, can also be relieved by regional sympathetic denervation. Bauer[116] reported an impressive series of eleven patients with intermittent attacks of severe renal colic. On urologic examination nothing abnormal was found with the exception of low-grade hydronephrosis and delayed emptying of the opaque medium from the pelvis or from a single calyx. All of these individuals developed their typical pain when tested by the ureteral distention test, and were relieved by careful dissections of all the nerve bundles that run along the renal pedicle and upper ureter. In a second paper[117] a five-year follow-up examination was reported as showing lasting good results with no evidence of functional impairment in the denervated kidneys.

The sympathetic fibers do not play an important role in micturition or conduction of bladder pain. Their action is primarily concerned with vasomotor control, while filling and emptying as well as vesical pain are mediated by the parasympathetic fibers in the second, third, and fourth sacral nerves. Workers at the Mayo Clinic have long been interested in the possible value of presacral neurectomy. Jacobson, Braasch, and Love[118] reviewed their extensive series of sixty-two cases and concluded that "the operation has been found wanting," although temporary or partial relief of vesical pain has often been observed. They found some cystoscopic evidence of relaxation of the muscular tissues in the region of the trigone and vesical neck, but concluded that other operative procedures such as transurethral resection "have proved to be of greater effectiveness in providing the desired relief."

Pain in Causalgia and Other Posttraumatic States.—The effectiveness of sympathectomy and increasing blood flow in the treatment of chronic painful states found after certain traumatic lesions of the extremities has been recognized since Leriche first described its value during World War I. Literature on this subject published prior to 1941 has been reviewed by White and Smithwick.[89] No animal experimentation has advanced knowledge as much as clinical experience in this field. Experiences in World War II have been particularly valuable in providing large numbers of cases for study with consequent better evaluation of the specific indications, the value, and the limitations of sympathetic interruption.

Unfortunately the mechanism which causes pain in such conditions as causalgia, postraumatic dystrophy (Südeck's atrophy), amputation neuralgia, etc. are still not known. Pain often develops in the presence of vasomotor and sudomotor dysfunction, and relief following sympathetic denervation is most likely to occur when these evidences of abnormal sympathetic activity are present. There is no valid evidence that sensory fibers run in the peripheral, as

distinguished from the visceral, nerve trunks, and the fact that Berry and associates[39] reported relief following intravenous injection of tetraethylammonium salts indicates that the site of interruption is on the side of the sympathetic motor outflow. Sensory axones, which run in continuity to the posterior root ganglion cells without a synapse in the paravertebral ganglia, are not interrupted by this drug. Therefore, as Mandl[119] aptly stated, "although we are successfully treating 'reflex dystrophy,' we are unable to explain the mechanism of the therapeutic effect."

In the preoperative evaluation of all these conditions the preliminary test by paravertebral injection with procaine is a most valuable method. Not only does temporary interruption of pain give a favorable prognosis for permanent relief by sympathectomy, but the action of chemical block is often prolonged. During this period active physiotherapy and mobilization of painful joints may be begun. Mahorner,[120] as well as many others, advocated a trial of repeated injection of procaine, and many patients have thereby regained use of the painful extremities without the need of surgical denervation.

In typical major causalgia, as described by Weir Mitchell during the Civil War, the relief of pain rarely lasts more than a brief period following diagnostic procaine block, but is nearly always permanent following sympathectomy. The impressive series of cases which has been reported to date following this method is shown in Table I.

TABLE I. SYMPATHECTOMY IN MAJOR CAUSALGIA

AUTHORS	NO. OF CASES	SATISFACTORY RESULT	FAILURE	COMMENT
Doupe, Cullen, and Chance[121]	5	5	0	1 incomplete sympathectomy failed to relieve pain until denervation was completed by secondary operation; 1 failure following periarterial sympathectomy
Speigel and Milowsky[122]	9	0	0	1 patient treated by paravertebral injection of alcohol
Mayfield and Devine[123]	12	12	0	
Allbritten and Maltby[124]	30	27	3	In 2 failures following lumbar ganglionectomy the level of sympathetic denervation did not reach the point of nerve injury
Rasmussen and Freedman[125]	40	29	11	Many patients listed as failures had only slight degree of residual pain
Ulmer and Mayfield[126]	58	58	0	
Total	154	131	14	

Successful results in causalgia depend on selection of typical cases of Weir Mitchell's syndrome. These generally follow a penetrating wound which has caused only partial injury of a peripheral nerve. They are characterized by burning pain and hyperesthesia of the hand or foot, with vasomotor, sudomotor, and trophic changes. All these patients have profound aggravation of the symptoms with excitement or emotion, and improvement when in a quiet environment, asleep, or after medication which reduces the activity of the sym-

pathetic discharge from the hypothalamus. Failure may result from incomplete sympathectomy or, in cases in the lower extremity, when the level of denervation has not been brought up to the level at which the nerve is injured. This means that in cases of injury to the upper portion of the sciatic nerve the sympathectomy may have to be carried upward as high as the eleventh thoracic ganglion (Ulmer and Mayfield[126]). The reason for this may depend on Doupe, Cullen, and Chance's[121] theory that causalgic pain is due to a short-circuiting at the point of nerve injury of the sympathetic motor discharge across to the somatic sensory fibers.

So-called reflex or postraumatic dystrophy of an extremity, which leads to spotty atrophy of bone as described in 1900 by Südeck, usually follows comparatively mild injury of the tissues without any definite lesion to a nerve. With the onset of spreading neuralgia and immobilization of the extremity, vasodilatation is generally present at first, although in the late stage the extremity is often cold and discolored. Miller and de Takats[127] and also Evans[128] published carefully conducted studies of their cases. In the first series treated by sympathectomy all patients did extremely well, with the exception of a single recurrence at the end of one year. Seven treated by repeated chemical blocks did nearly as well. Of three others, treated by periarterial sympathectomy, one had an excellent and two mediocre results. It is of interest that only in this condition have a number of American writers reported favorable results from arterial stripping.

Evans published the results on fifty-seven patients treated at the Lahey Clinic during the last five years. Of twenty-nine submitted to sympathectomy, twenty-two obtained satisfactory to complete relief of pain. Eleven others obtained adequate relief following one or more sympathetic nerve blocks with procaine, sometimes reinforced by local injection of "trigger areas."

Neuralgia in peripheral amputation stumps, related to excessive coldness and moisture, can often be relieved by sympathetic surgery (White[129]), but few successful cases have been reported after amputations above the wrist or ankle. Major amputation-stump neuralgia of this sort usually requires a cordotomy for relief, but if there is a superimposed element of phantom pain this may not be effective. Woodhall,[130] who performed a sympathectomy for a combined phantom hand with burning sensation in the lower forearm stump, was able to secure complete relief of the latter without any alteration in the phantom.

In concluding this review of the painful posttraumatic syndromes it is well to stress the importance of early effective treatment. Watchful waiting, in the hope that severe pain will disappear spontaneously, is not advisable for more than a very limited period. The surgeon should consider active intervention as soon as he is convinced that conservative orthopedic, physiotherapeutic, and psychiatric measures are unavailing.[129] He should bear in mind that repeated resection of neuromas, neurolyses, neurotomy, and posterior root section have all failed consistently. Each useless surgical intervention will make ultimate cure more difficult by adding further psychic trauma and further reduction in the patient's morale. As de Takats[131] has written, "in cases of the late severe

form, the spreading neuralgia may involve the shoulder, the thoracic wall and the opposite limb. The patient has a severe psychoneurosis, either because of his original make-up or because of continued, unrelieved pain.'' Add to this a compensation complex or narcotic addiction and the problem may become insoluble. In these situations, section of the spinothalamic tract has often failed. The most hopeful method of rehabilitating such individuals is by bilateral frontal leucotomy.

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In Memoriam

Elliott Carr Cutler
1888-1947

IN THE premature death on Aug. 16, 1947, of Elliott Carr Cutler at 59 years of age—recipient of the Bigelow Medal of the Boston Surgical Society in 1947—medicine and surgery throughout the world have lost a virile figure and beloved teacher; his community has lost a loyal, generous friend; and his country a soldier who gave his life for her as surely as if a bullet had snuffed it out during his long years of battlefront service. Taken ill while still on active duty, his true disability unrecognized despite his own sure knowledge that he was a sick man, his devotion to his work made him as expendable as any soldier of the line.

Not until his job was complete and he had returned home was the true nature of his malady recognized. Very few men could, or would, have faced the next two years with the courage, cheerfulness, optimism, and refusal to quit which he showed. A great soldier is gone.

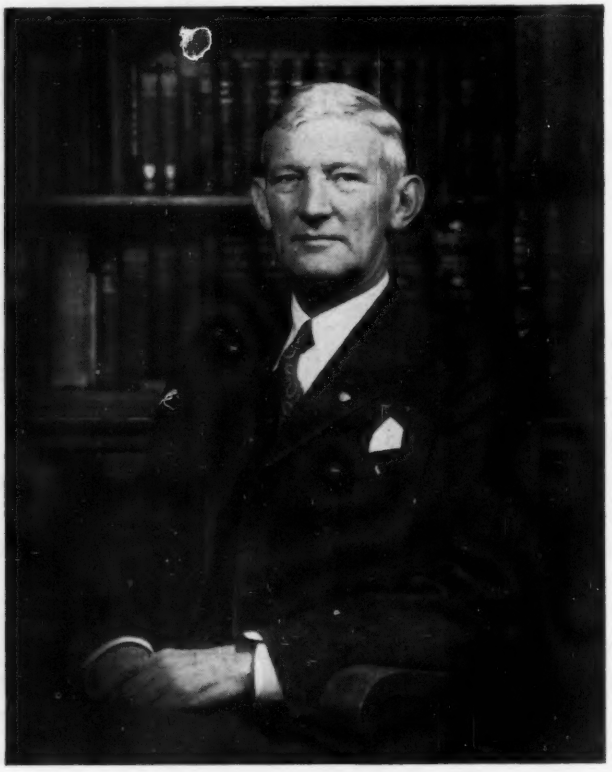
Elliott Cutler was born in Bangor, Maine, July 30, 1888, of sturdy colonial heritage, stemming from our earliest history. As a young man he gave prompt indication of the driving energy, lofty ambition, and love of a good fight so characteristic of his whole life. Both public and private schools in Brookline, Mass., set his feet in the educational pathway. He entered Harvard in 1905 where his scholastic record was one of distinction, and where he found time as well to captain a victorious Harvard crew. He graduated from Harvard Medical School *cum laude* in 1913, doing special work in pathology during his fourth year under Dr. F. B. Mallory at the Boston City Hospital.

The following summer was spent at postgraduate work in Heidelberg under Professor Krehl. He returned to become the ardent pupil of Dr. Harvey Cushing at the Peter Bent Brigham Hospital as a surgical house officer. In 1915 and 1916 he was resident surgeon at the Massachusetts General Hospital, and followed this with one year's work under Dr. Simon Flexner at the Rockefeller Institute. His first war experience came immediately after; a period of willing and distinguished service for which he seemed especially adapted, and which gave him his first award of the Distinguished Service Medal and a personal citation from General Pershing.

He returned to the Brigham Hospital as chief resident surgeon in 1919, serving for two years in this post. His climb up the academic ladder from that time was rapid and sure. He became professor of surgery at Western Reserve University School of Medicine in Cleveland in 1924, and director of the surgical service at the Lakeside Hospital. On the retirement of his teacher, Dr. Cushing, he came back to Boston as Moseley Professor of Surgery at Harvard, and as

Surgeon-in-Chief at the Peter Bent Brigham Hospital. His great and oft-expressed ambition was to teach Harvard medical students, and knowing how much he admired and even subconsciously copied many of Dr. Cushing's characteristics, it is understandable that this post seemed to him the crowning touch of his academic career.

He was one of the first to recognize the inevitability of our participation in World War II. In addition to his hospital and medical school work in the days preceding universal recognition and the actual step of war declaration, he worked long hours in the organization of civilian safety here at home. He was largely responsible for imbuing many of his pupils and colleagues with the need to organize themselves early into a new base hospital ready for their country's



Elliott Carr Cutler
1888-1947

call. It is understandable that he could not leave them to face such service alone. In July, 1942, with the approval of the University and the Hospital, he became active again in the Army of the United States as a colonel in the Medical Corps. He became Chief Surgical Consultant in the European Theatre of Operations from August, 1942, to February, 1945, and Chief of the Professional Service Division from February, 1945, to August, 1945, with the rank of Brigadier-General.

Major-General Paul R. Hawley, Surgeon-in-Chief of the European Theatre, has spoken of him in the following terms: "His wisdom and his wide experience

made him invaluable. His inexhaustible energy became proverbial among his fellow officers. He organized, he planned, he criticized, he praised. He was here, he was there, and he invariably subordinated his personal comfort and the prerogatives of his position to the task at hand. To him, more than to any other man, is due the credit for the fine medical care given the wounded in the European Theatre.''

As a surgeon he was not spectacular. His technique was a direct heritage from Halsted, through Cushing. His pupils have all often heard his admonition —''These tissues are mostly water; we must never forget this!''—a typical exaggeration for the sake of emphasis. Careful hemostasis, gentleness, and a sacrifice of speed to obtain other more vital things as exposure and avoidance of trauma made his operations frequently lessons in anatomy for his assistants. He believed wholeheartedly in the importance of preoperative and postoperative care, more often than not doing the dressings himself and always seeing his patients daily. His best known work is remembered as his insistence on the embolic theory of postoperative pulmonary complications as opposed to the widely accepted belief that inhalation played the major role; his pioneer work in cardiac surgery; and his work in the relief of congestive heart failure through the medium of total thyroidectomy. He will be remembered as the surgeon who performed the first pericardiectomy in this country and who successfully carried out the first direct operative attack on the stenosed postrheumatic mitral valve. It was his pioneer work in this field which laid the foundation for the present-day spectacular enlargement of this field which we all know so well in the work of Beck, Elkin, Gross, Blalock, and others.

As a teacher he maintained that the fundamentals of good surgery should be presented to the students by senior teachers, and acted on this preachment. His own long training in pathology and laboratory study was all that was needed to emphasize his insistence on such preparation among his pupils. A large number of his published writings dealt with the education of the surgeon, a subject upon which he was always ready to speak; in fact, this was the subject of his Bigelow Medal Address, his last published work. In spite of many problems of personal interest which his restless, even somewhat feverish mind, urged him to pursue personally, he was always ready with helpful, pertinent suggestions in connection with the work of his younger colleagues. The weekly ''Surgical Teas'' over which he presided in his beloved surgical laboratory, where over a cup of tea and a biscuit all the younger staff listened to one of their fellows present his work for general discussion, were stimulating beyond measure for these young men. It was here more than anywhere that his breadth of interest and wide familiarity with almost every phase of modern surgery showed itself to its best advantage. A nearly continuous stream of distinguished visitors—his personal friends—were regularly taken to these exercises and brought into the friendly, informal discussions. The Laboratory to Dr. Cutler was the proving ground for any new or difficult clinical problem.

He was a prolific writer (his publications numbered well over 260) and an exceptionally able administrator. The duties incident to conducting a busy department of surgery, so often the greatest hindrance to scientific productivity,

never bothered him. Budgetary limitations meant nothing to him. If the need arose, one or another of his host of friends seemed always ready to listen to his persuasive tongue and supply the necessary funds.

It is not possible here to enumerate all the honors which were his. He belonged to forty medical societies in many of which he held important offices. Even as the end came he was busily planning, as President of the American Surgical Association, for its meeting in 1948. Seven medical journals listed his name on their editorial boards. Honorary university degrees were his, and among his ten military decorations are three from the governments of England, France, and Norway. Few families can boast the proud story of patriotic service of the Cutlers during the last war. Twenty members of his family served in the armed forces, among them one commodore and two generals. Topping this remarkable record stands General Cutler's own, for his was a service of help and rehabilitation to the wounded. He alone in our military history stands out as the only medical officer to have received two Distinguished Service Medal awards.

But those who knew him best will not so much remember him as a great surgeon, a stimulating teacher, a person of many talents and unbounded energy, a charming host and wonderful companion, but as a man who faced with supreme courage, in a manner few may duplicate, those darkest hours of his last two years—a man to whom the laying down of arms was unknown.

His career and achievements furnish inspiration for all, and afford an example any young man might hope to emulate—never was it more inspiring than during the last long months. He found his own reward in his consciousness of service, in the approval and recognition of his fellows, and in seeing his own great desire to improve the medical care given to our sons and daughters who served in the armed forces become a reality.

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